MARCH 21, 1957
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION

Speed Reducers and Gearmotors

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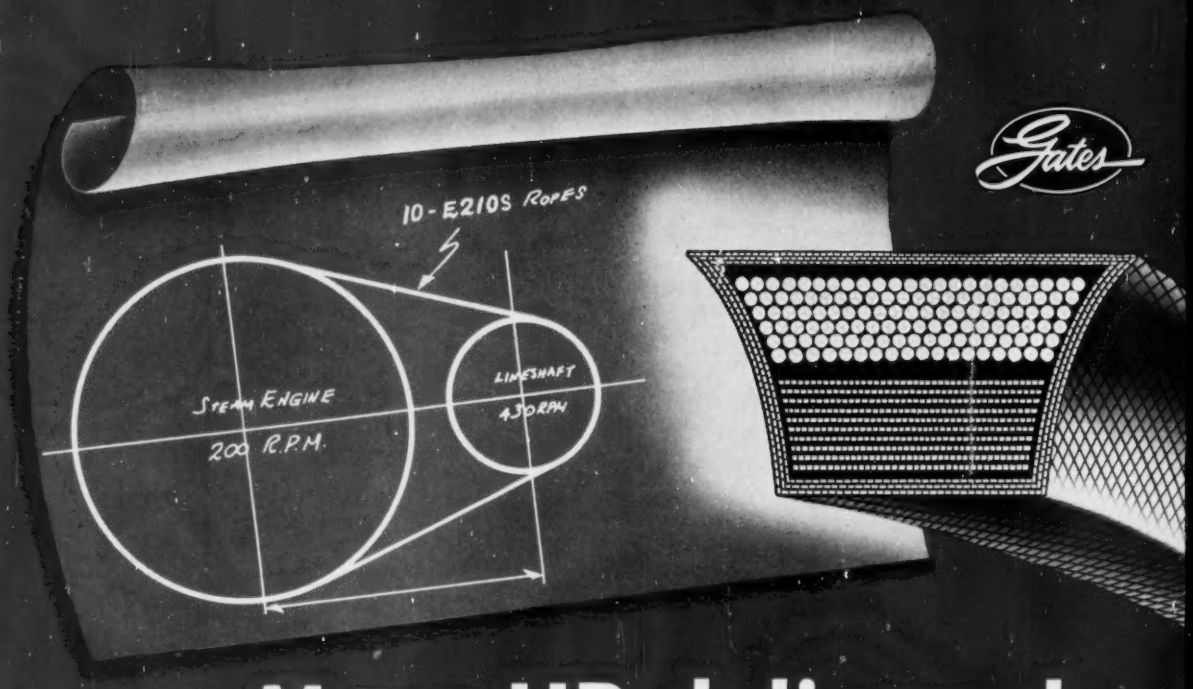
FARNSWORTH

FARNSWORTH



More HP delivered per $ invested

On any new drive design—where you have limited space or you need to keep weight down—here is an important fact that can save you money:

A Gates Super Vulco Rope drive will deliver more horsepower per dollar invested than any standard V-belt drive.

Actually, the greater load carrying capacity of Super Vulco Ropes cuts down the number of belts required (5 Super Ropes do the work of 7 standard belts) . . . thus reducing the width of sheaves.

Sheaves with fewer grooves not only cost less, they weigh less, and take up less room—advantages that can easily improve the design and lower the overall cost.

A wealth of drive data is quickly available to you. Simply call your nearby Gates V-Belt Distributor for a Gates V-Belt Specialist. Stocks available in industrial centers around the world.

The Gates Rubber Co., Denver, Colorado
World's Largest Maker of V-Belts

4 BIG PLUSES

+ Handles shock loads

Super-strength cords provide 40% greater horsepower capacity . . . easily absorb heavy shock loads.

+ Provides Static Safety

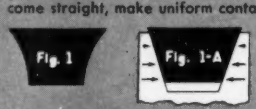
High electrical conductivity is built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

+ Resists oil, heat and weather

Special rubber compounds with which cords and fabric are impregnated make Super Vulco Ropes highly resistant to heat, oil and prolonged exposure.

+ Wears far longer

Concave Sidewalls (Fig. 1) increase belt life. As belt bends, concave sidewalls (U.S. Pat. No. 1813698) become straight, make uniform contact with sheave groove (Fig. 1-A). Uniform contact means less wear on sides of belt . . . longer V-belt life.



Flex-Weave cover (U.S. Pat. No. 2519590) provides greater flexibility with far less stress on fabric. Cover wears longer—increases belt life.

Gates Super VULCO ROPE Drives

TPA 76c

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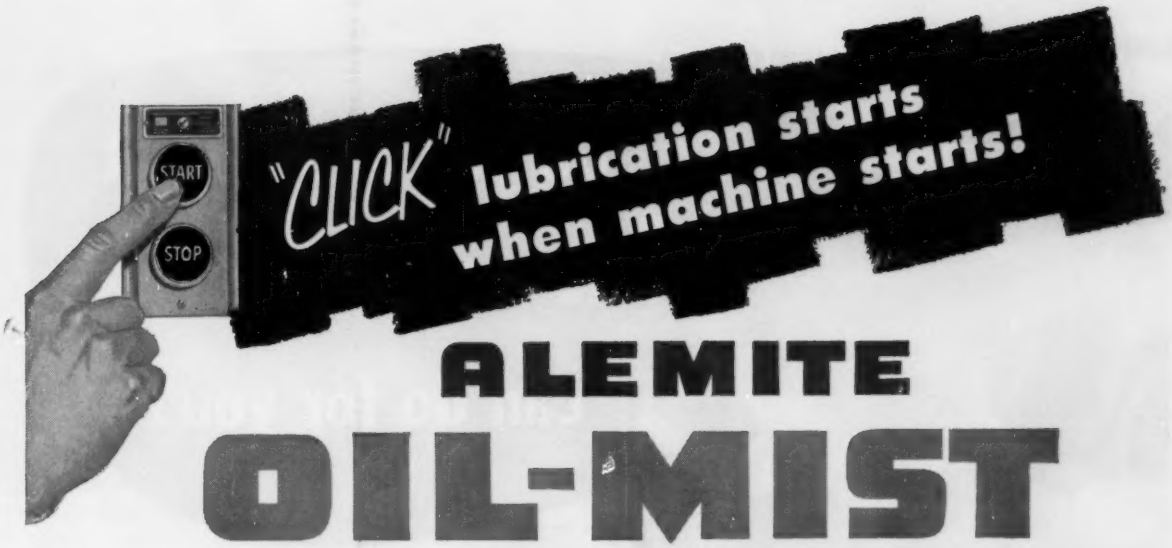


ALEMITE OIL-MIST AUTOMATIC LUBRICATION

provides constant, foolproof uniform lubrication— to protect *any* moving surface!

Alemite Oil-Mist lubrication can be easily designed into any new or installed machine. This simple, continuous, completely automatic system eliminates human error—multiplies bearing life—reduces product spoilage—boosts machine output! Operates on compressed air . . . starts and stops when machine switch is turned on and off. Airborne lubricant is conveyed through tubing to bearings. Mail coupon below for full details about Alemite Oil-Mist. Now in use on modern, high-speed machines.

Lubricates any bearing on any machine with one of three types of fittings:

Mist fittings for roller, ball, needle—or any anti-friction type of bearings.

Spray fittings for open and enclosed gears and chains.

Condensing fittings for plain bearings, slides, ways, vees, cams, and rollers.

8 Advantages of the Alemite Oil-Mist System

1. Continuous lubrication. Deposits fresh, clean film of oil on all surfaces of all bearings.

2. Fully automatic. Starts and stops with operation of machine switch.

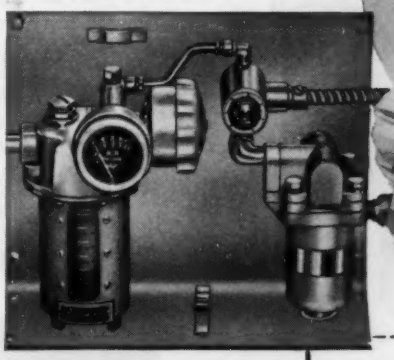
3. No guesswork. Bearings can't be overlooked, or over-lubricated!

4. Reduction of bearing temperatures. Acts as bearing coolant. Reduces bearing temperatures as much as 20°F.

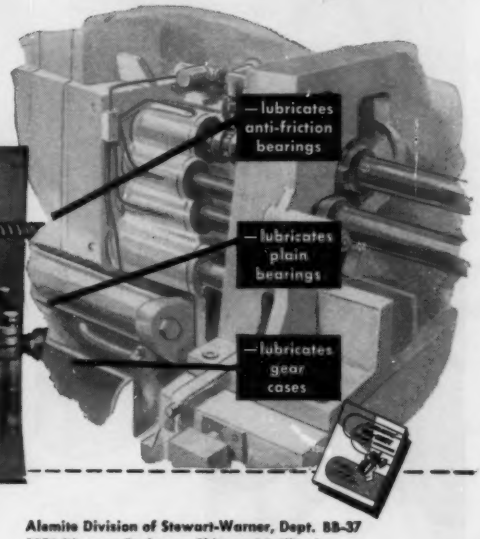
5. Fewer types of oil. Reduces number of oils that must be stocked, handled and applied.

6. Elimination of downtime. All bearings are constantly lubricated while machines continue to operate.

7. Extension of bearing life. Life of grinding machine bearings have been extended from 400 to 7,000 hours!



8. As high as 90% less oil consumption. Usually consumes about 1/10th amount used by any other oiling method.



Mail coupon for Oil-Mist demonstration and information

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Division of STEWART-WARNER CORPORATION

Alemite Division of Stewart-Warner, Dept. 88-37
1850 Diversey Parkway, Chicago 14, Illinois

☐ Please send me a FREE copy of your new and complete Oil-Mist catalog.

☐ Please have your Alemite Lubrication Representative arrange a no-obligation demonstration.

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City.....Zone.....State.....

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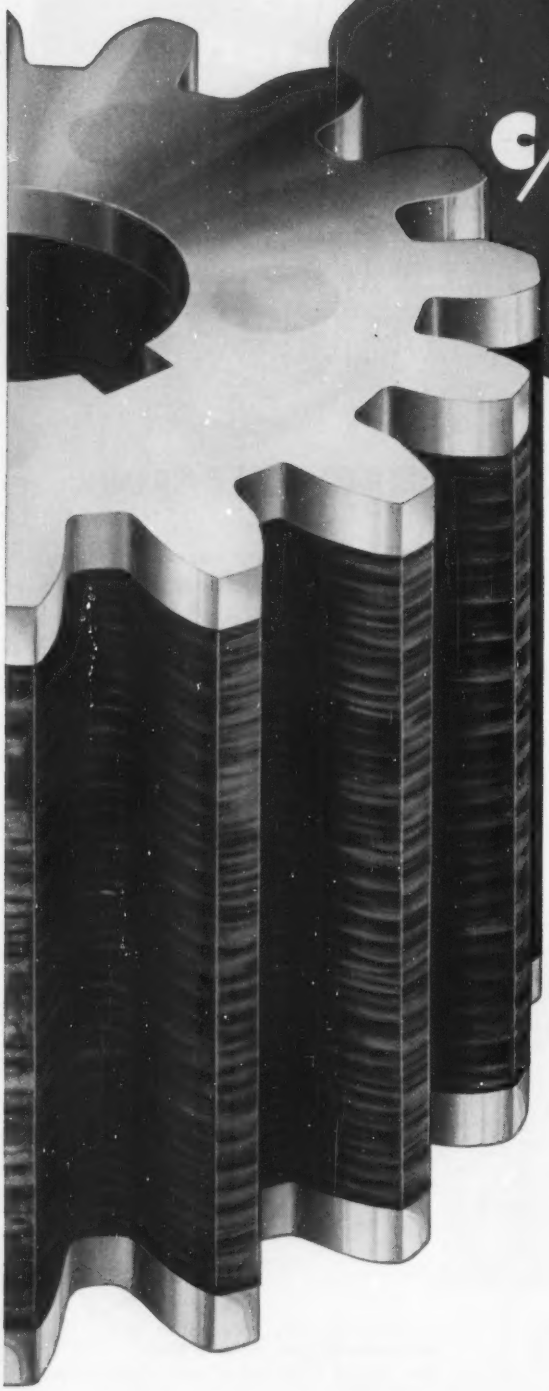

Do you know what C/R RAWHIDE GEARS can do for you?

HERE'S WHAT—They will transmit power quieter, with less vibration than other types of gears. These tough, resilient Rawhide gears will absorb momentary overloads up to 3 times their rated H.P. capacity . . . protecting expensive metal gears. Since C/R Rawhide pinions cause negligible wear, they actually prolong the life of mating metal gears.

MORE FACTS—They require no lubricant, are nonconductors, and are extremely durable. Rawhide spur gears are cut in sizes from 1″ O.D., ¼″ face up to 30″ O.D., 12″ face. D.P.'s range from 48″ to 1¼″; horsepower ratings go up to 50 H.P. or more. Where high temperature and humidity are factors, C/R gears cut from Nylon, Fabroil, Bakelite, or Micarta may be more suitable.

ASK C/R—We've been cutting non-metallic spur, helical and bevel gears for all types of applications for over 74 years. May we help solve your gear problem?

Please write for illustrated C/R Gear Booklet.

GEAR C/R DIVISION

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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

March 21, 1957
Volume 29—No. 6

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MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations performing design engineering of products are also eligible.

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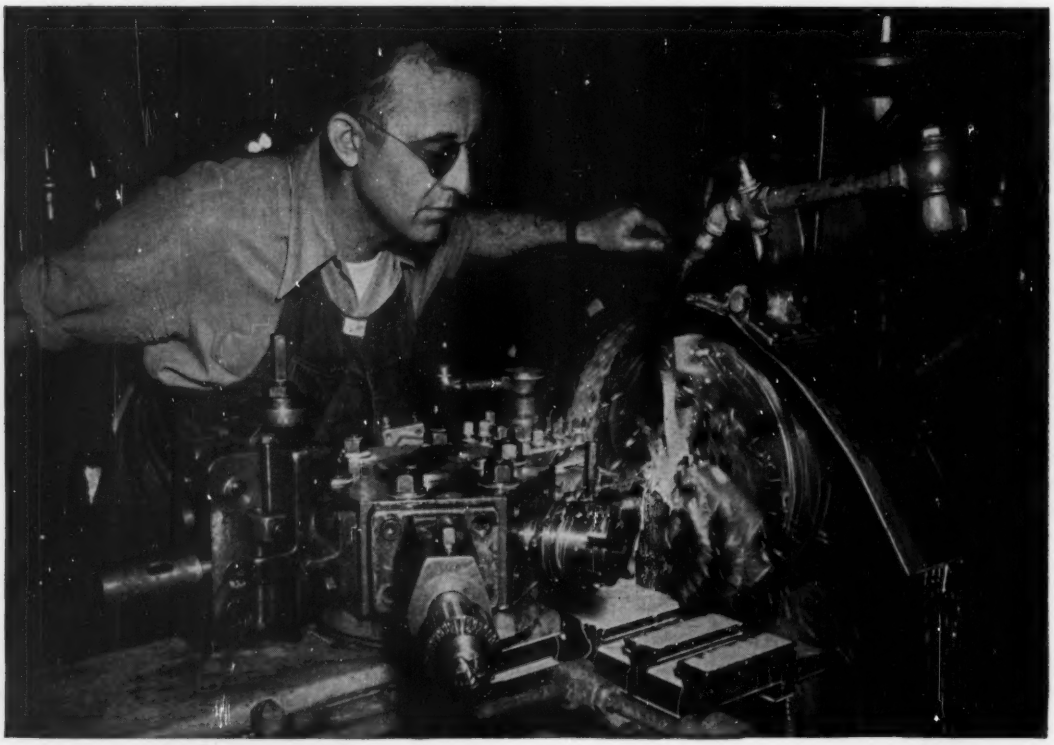

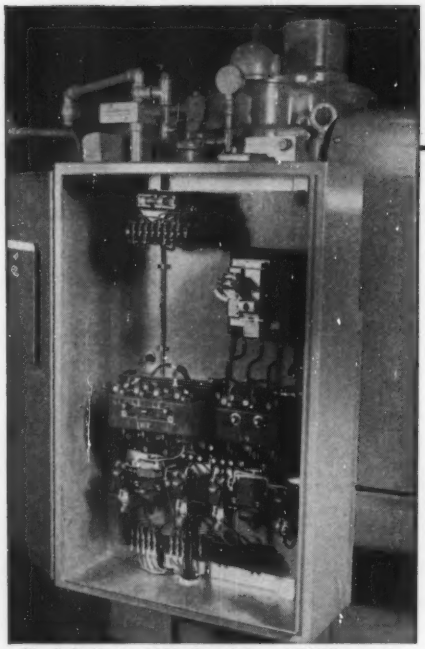

Clark Bulletin 6050, Size 2 Type "CY" Starter for Single Winding 2 Speed Constant Torque A.C. Motor used on Warner & Swasey Universal Turret Lathes.

CLARK CONTROLS help Warner & Swasey lathes

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● Selected for long, trouble-free performance, Clark Bulletin 6050 Size 2, Type "CY" 2-speed starters are used on Warner & Swasey's No. 5 Universal Turret Lathes. Maintenance and wear on contact tips are reduced to a minimum as a result of an exclusive arc quenching method employed on Type "CY" starters. Effective arc interruption and reduced wear on tips is accomplished by using strong multi-turn magnetic blowouts and double-break contacts. Forced rotation continuously moves the arc from a hot to a cold spot, distributing the heat evenly over entire contact, preventing pitting or "build-up." Tips require no cleaning or dressing over long years of maintenance-free operation.

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Engineering News Roundup

BOOM WILL BE LOWERED to ride out hurricanes after this 120-ft missile-launching tower, built by Noble Co., is delivered to the Air Force and put to use in Florida. The top 110 ft, shown here near vertical position, tilts 90 degrees in 11 minutes. Nontilting base is 10 ft high, 30 ft wide, 60 ft long. Base carries power and controls for tilting, and for moving tower and missile on its own two-track railroad. Power also changes elevations of five platforms each of which gives 360-degree access to missile. Platforms are reached by elevators, one on each of the tower's legs.

Biggest Design Show-Conference Planned in New York, May 20-23

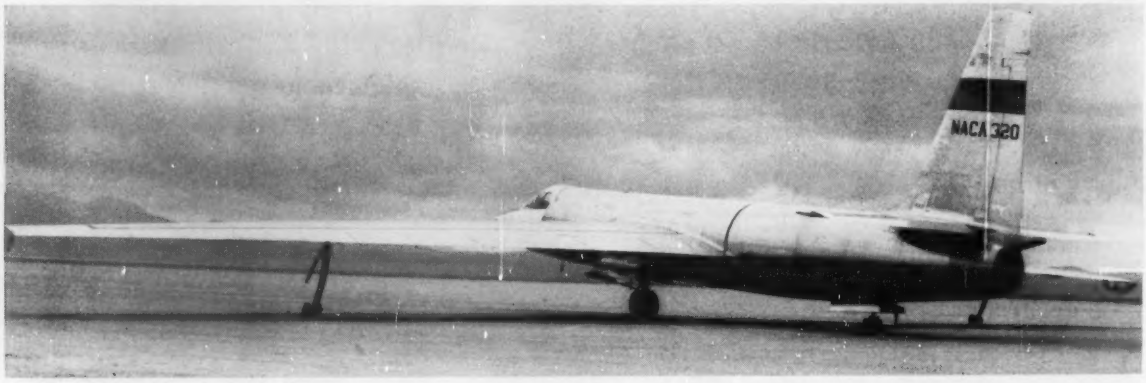
Designers to See More Exhibits, Have Choice of Paper Sessions

NEW YORK, N. Y.—On May 20 to 23, this city's Coliseum will be the site of the 1957 Design Engineering Show and Conference which promises to be the country's biggest event of this kind. Planners have been spurred by success beyond most estimates with the first Design Show and Conference in Philadelphia last year. The second will have more technical sessions, more displays, more attendance.

About 340 companies have arranged to exhibit products, components and services of direct concern and benefit to engineering designers and executives. Exhibits will be open during afternoons of the show days.

Program sponsor is the ASME. Arrangements for the society are being made by George Habach, chairman of the ASME Machine Design Committee, and Charles Marks, chairman of the New York Metropolitan Section, Machine Design Division.

Feature of the conference plan



HIGH SKY LABORATORY is the U-2 built by Lockheed and used by NACA to obtain detailed information about gust-meteorological conditions at high altitudes. Powered by a Pratt & Whitney J-57 engine, the U-2 carries data-gathering instruments to 55,000 ft. Its ability to maintain this altitude is its particular usefulness. Subjects under study include clear air turbulence, convective clouds, and the jet stream.

is that guests will have a choice of technical sessions on May 21 and 22. Conference details now available are the following:

Monday, May 20—10:00 a.m.

Subject: *Procedures in Developing New Designs.* A question and answer panel session, including running questions from the floor.

Moderator—George Nordenholt, Editor, *Product Engineering.*

Panel Members—T. M. Butler, Director of Engineering, Burroughs Corp.; Myron S. Curtis, Engineering Vice-President, Warner & Swasey Co.; George F. Habach, Vice-President, Engineering, Worthington Corp.; Robert H. Hose, Partner of Henry Dreyfus Associates, and Past-President, American Society of Industrial Designers; William J. Russell, Vice-President, Engineering, Landers, Frary & Clark; Walter Dorwin Teague, Walter Dorwin Teague Associates, and Past-President, American Society of Industrial Designers.

Tuesday, May 21—9:30 a.m.

MECHANICAL SESSION

New Developments in Design and Application of Gearing. By Darle W. Dudley, Advanced Design Engineer, Gear Engineering, General Electric Co., West Lynn, Mass.

New Developments in Design and Application of Cams. By Harold A. Rothbart, Professor, Dept. of Mechanical Engineering, City College of New York, New York, N. Y.

MATERIALS SESSION

Metallic Materials. By C. R. Simco, Principal Metallurgical Engineer, Battelle Memorial Institute, Columbus, O.

Ceramics and Refractory Materials. By John H. Koenig, Director, and Edward J. Smoke, Professor, School of Ceramics, Rutgers University, New Brunswick, N. J.

ELECTRICAL SESSION

Selecting Motors with New NEMA Frame Sizes. By Earl Barnes, Assistant Chief Engineer, Reliance Electric and Engineering Co., Cleveland, O.

Field of Application of Static Controls. By Robert A. Mathias, Professor, Dept. of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

Wednesday, May 22—9:30 a.m.

MECHANICAL SESSION

Designing for Easier Machining, Handling and Assembly. By Kurt O. Tech, Vice-President in Charge of Engineering, Cross Co., Detroit, Mich.

Hopper Feeding. By Floyd E. Smith, President, Perry Equipment and Engineering Co., Erie, Pa.

MATERIALS SESSION

Plastics and Rubbers. By Wyman Goss, Manager, Phenolics Engineering, Chemical Materials Dept., General Electric Co., Pittsfield, Mass.

Coatings and Finishes. By H. J. Reindl, Supervisor, Research, and Development—Finishes Section, Inland Manufacturing Div., General Motors Corp., Detroit, Mich.

ELECTRICAL SESSION

Numerical Control for Machinery. By Claude D. Coffin, Senior Electrical Engineer, Warner & Swasey Co., Cleveland, O.

Designing Machines for Automatic Controls. By C. B. Sung, Manager, Mechanical Development Section, Research Laboratories Div., Bendix Aviation Corp., Detroit, Mich.

More Engineers Seen In Top Management

Diversified Background Advised For Engineers Who Seek to Lead

LOS ANGELES, CALIF. — Engineering has reached a "golden age" in which members of the profession are increasingly favored for top management positions. "The very nature of modern industry makes this inevitable." These were remarks of Donald W. Douglas, president of Douglas Aircraft Co., speaking at a recent Engineers' Week banquet during which he received a special award for his accomplishments in aircraft and missiles engineering.

"The technological developments of recent years . . . have had a profound impact on our whole industrial structure. More and more, top management is forced to turn to the man with an engineering background." Mr. Douglas urged engineers with management ambitions to acquire as diversified a

Front Cover

Bold and black, artist George Farnsworth's front cover design emphasizes the power transmission aspects of worm-gear reducers. Cover-theme article is by associate editor Bill Miller —a feature section on "Speed Reducers and Gearmotors" on Page 121.

HANNA CYLINDERS

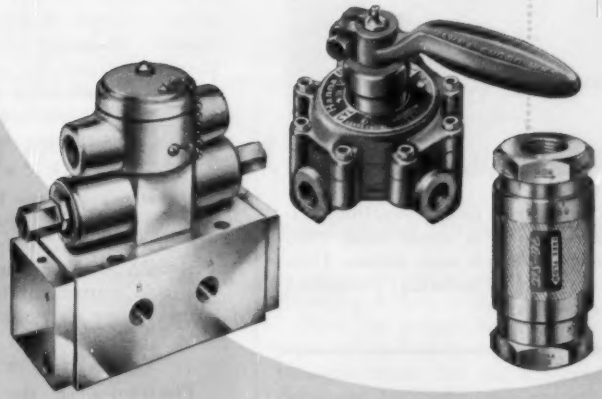
There is a complete line of Hanna Cylinders to suit all requirements of size and mounting . . . in capacities up to 250 psi for low pressure air or hydraulic operation, and up to 1500 psi hydraulic.

. . . finest combination

for Dependable Fluid Power

and Reliable Controls

HANNA VALVES



Designed to assure most efficient control, there are many types and sizes of Hanna Valves available for hand, foot and electric operation, for automatic, remote and speed controls.

It may not take over half a century to design and build a superior line of cylinders and valves . . . but the experience a company compounds in that time surely helps. Hanna has that background.

What does it mean to You, today—in terms of cylinders and control valves? — Basically these important things:

- Products designed and manufactured to the very highest standards of performance . . . not built down to a price—although they are competitive.
- A line so complete that you can specify a "standard" Hanna cylinder or valve to suit your "special" jobs.
- A plant engineering staff that backs a nationwide regional engineering-sales organization to help you quickly solve difficult problems—and to follow through on all your "needed now" requirements. Many Hanna Representatives stock the standard sizes and types of Hanna Products—the Hanna Plant, of course, does, too.

Whether you need cylinders and controls for equipment that is for resale, or for your own plant use . . . call or write your Hanna Representative (see classified telephone directory or Thomas' Register) or write us direct.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

1751 Elston Avenue, Chicago 22, Illinois

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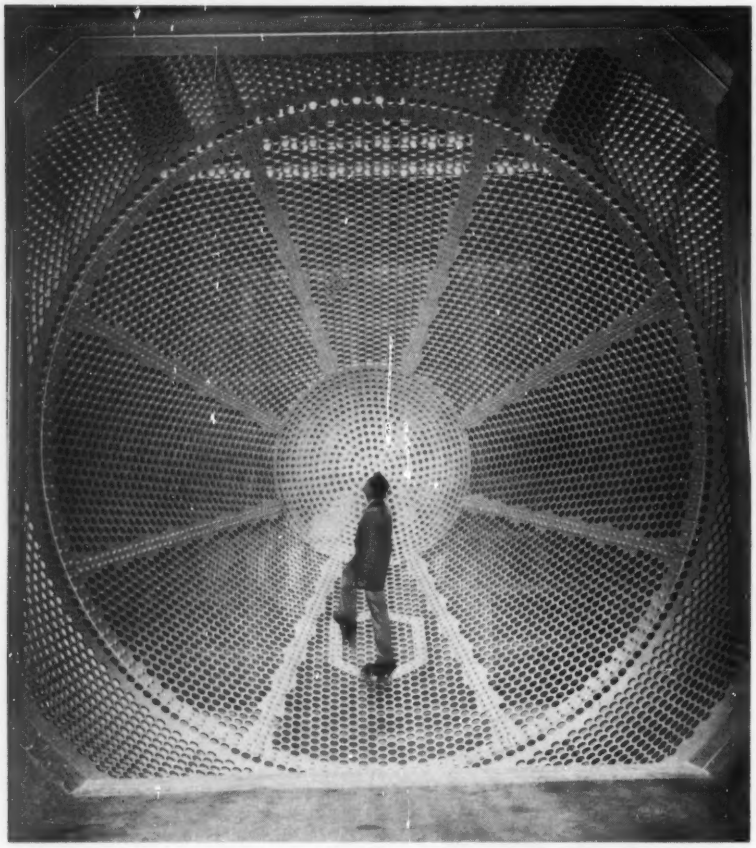


DIFFUSION SCREEN in North American Aviation's new $5-million Trisonic Wind Tunnel looks like a giant-size colander. It could hold 7500 bushels of potatoes. Its size is also indicated by the 6-ft man shown. During a test blow, the screen diffuses air into a muffler building, protecting sound-proofing materials from sudden, uneven shock.

background as possible, including a knowledge of fields outside their own profession.

He emphasized the engineer's function as "the agent through which our expanding knowledge of the universe is transformed into something of tangible value to the people of the world. . . . It is my hope that we do not wander too far from this down-to-earth concept."

Douglas called for a careful appraisal of the balance between research and practical engineering in the nation's defense effort. "In our striving to find the ultimate weapon of tomorrow, we should not neglect the weapons of today. For that is when we may need them. . . . My concern is that we keep the ratio in balance."

More Power, 52-Inch Height Seen in Future Cars

Sealed Chassis Components, Rear-End Warning in Prospect

FORT WAYNE, IND.—Cars of the near future are going to be even lower and more powerful than today's and will have added driving safety and comfort. These features were forecast recently by Victor G. Raviolo, director of advance product study and engineering research on the engineering staff of Ford Motor Co.

"There is no doubt that everyone wants a lower car—and this is fundamentally correct since it will have less frontal area and less wind resistance. Today's cars are in the range of 56 to 61 in. high—tomorrow's will be lower. There

Topics

Atomic curing of rubber has been accomplished by B. F. Goodrich Co., whose scientists produced an automobile tire by means of radiation. The company says the process results in a direct linking of the carbon atom chains of the rubber molecules, forming a stronger material than conventionally vulcanized rubber, in which carbon atom chains are linked through sulphur atoms. Laboratory tests indicate the tire has better resistance to abrading, aging and deterioration. Commercial atomic curing of tires is seen at least ten years away by Goodrich; not at all by some other rubber producers.

• • •

Studying what goes down may aid in the design of intercontinental missiles that go up beyond the earth's atmosphere. Studies of meteorites have been suggested as a source of information to missile designers to indicate changes, caused by aerodynamic heating and abrading forces, that occur when materials enter the earth's atmosphere.

• • •

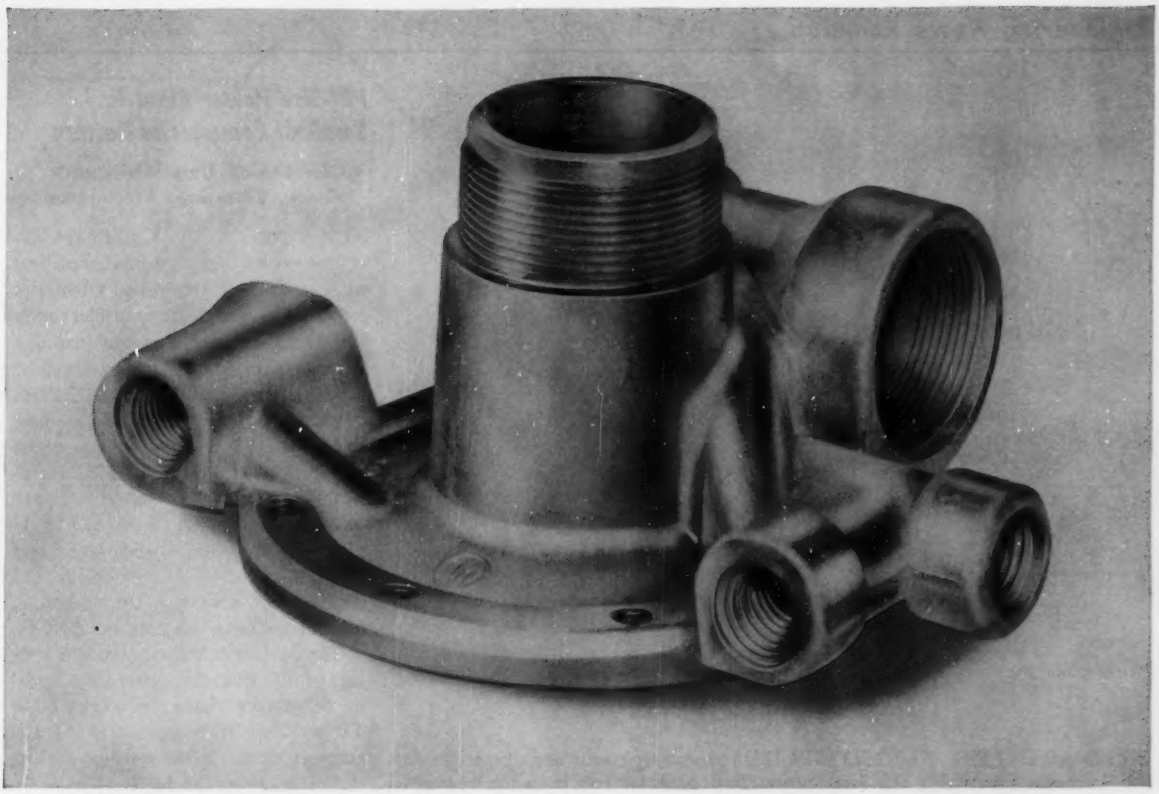
Diesel-powered gas turbine is to be developed by Solar Aircraft Co. for the Navy. It will be used as the main propulsion unit in landing and patrol crafts or as a prime mover for a ship's generators.

• • •

Electronics on the party line eliminates all unnecessary ringing of hand-crank type telephones, two million of which are still in use. An instrument called Secoder checks all rings coming over the line and sounds off only on the particular ring for which it is coded. Secoders, which also hinder the activities of eavesdroppers, are made by Electrical Communications Inc.

• • •

New pellet extrusion process for magnesium alloys is said to result in as much as 40 per cent increased strength. The process employs 0.016-in. spherical pellets instead of solid magnesium bars. Small size of the pellets produces fine grain structure and therefore high strength in the finished sections. Dow Chemical Co. developed the process for the Air Force.

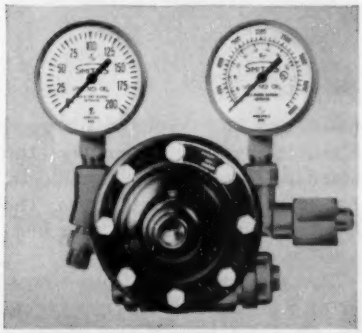


Anaconda Die Pressed Brass Forging after machining, ready for assembly in the gas-pressure regulator shown below.

Better regulators at less cost—with die pressed forgings

Save 25% in first cost—cut machining time, tool cost

Smith Welding Equipment Corp. of Minneapolis uses Anaconda Die Pressed Brass Forgings for gas-pressure regulator bodies as a result of the following analysis of the job.



Smith's two-stage oxygen regulator, Model H313. One of the Smith Welding Equipment Corp. products using Anaconda Die Pressed Brass Forgings.

First, die pressed forgings make a superior product because the twice-wrought metal has the uniformity, denseness, toughness, and strength to prevent gas leaks and to withstand pressures that run in excess of 2500 psi. And second, the forgings do the job economically. The initial cost of the die pressed forging is 25 percent less than the cost of sand castings. In addition, savings are realized in substantially reduced tool costs and machining time. And finally, the forgings are finished in a simple bright-dipping operation, with savings over sand castings estimated at 5 cents a unit.

SHORT CUTS: Anaconda Die Pressed Forgings are short cuts to superior products. Because of their high strength, hardness and resistance to impact, abrasion, and corrosion, they serve better functionally, often replacing more costly built-up assemblies of cast, stamped, drawn, or other machined parts. Their consistent accuracy of dimension eliminates most surface machining to size, permits trouble-free use of drilling jigs, threading or milling fixtures, broaching vises in secondary operations. They are ideally suited to high-speed automatic chucking machines.

The die pressed forging technique is practically unlimited in diversity of shape and field of application. Specialists at The American Brass Company will be glad to submit estimates on the cost of forgings for your critical components. Just submit a sketch or sample of the part involved—or write for Publication B-9. Address: The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Limited, New Toronto, Ontario.

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ANACONDA® COPPER ALLOY DIE PRESSED FORGINGS

Short cuts to superior products

FIELD ARTILLERY GUIDED MISSILE for surface-to-surface operations is the Lacrosse for which the first production contract has been awarded to Glenn L. Martin Co. Lacrosse is an all-weather missile intended to supplement artillery and close-support aircraft. Lacrosse system components are the missile, a launcher on a standard Army truck, and a guidance system. In flight, Lacrosse is propelled by a solid-fuel rocket motor. Units armed with the missile will be able to respond to calls for fire as quickly as units having conventional artillery. Rate of fire will be like 105-mm howitzer.

are engineering problems to solve, but we will have 52-in. high cars within 10 years."

With lower heights, it will be necessary to develop means of entering cars at least partially through the roof. This may be done by means of sliding roofs, tilting canopies or butterfly doors.

Further horsepower increases are also in prospect, due to continued demand for improved performance and power-using accessories such as air-conditioning. Today a full complement of accessories absorbs up to 45 hp.

Mr. Raviolo predicted further important developments in the field of highway safety and accident prevention. "Accident reports from the expressways and turnpikes point up the rear-end collision. As vehicle speeds increase, it becomes more difficult to judge the rate of approach to another vehicle. The ultimate answer will be a warning device which will operate so as to allow for safe deceleration."

In the field of driver comfort, Mr. Raviolo envisaged a completely air-conditioned car interior. "Heat will be added or removed as required, while clear, filtered air is evenly distributed to every part of the compartment. Windows will be normally sealed, provided with an emergency release. The windows can be made flush with the outer skin (exterior of the car) for smoother air flow and for substantial noise reduction."

He predicted big changes in seats, such as ventilation through the seat material as a boon to summer drivers and passengers. Engine life, almost doubled in the past 10 years, will be extended even further. "I expect to see sealed transmissions and axles, and lifetime lubricated chassis components that would not be serviced except in the case of real failure."

Pill-Size Power Plant Is Smallest Commercial Battery

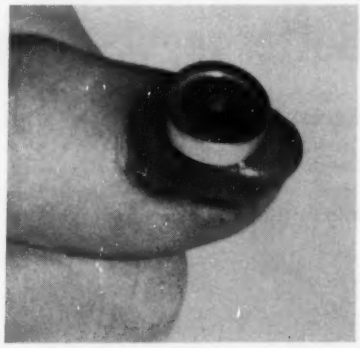
Gold-Plated Unit Withstands Shock, Vibration, Acceleration

NEW YORK, N. Y.—Significant developments in miniaturization were increased recently with the announcement of the new Eveready W-307 energizer, a miniature dry battery said to be the smallest of its type ever mass-produced. First commercial application of the new battery is in the electric wrist watch recently announced by Hamilton Watch Co.

Weighing only 0.05-oz, the energizer is 0.44-in. in diameter and only ⅛-in. thick. It is made exclusively of nonmagnetic materials, and occupies a volume of 0.31-cc.

The battery has a nominal rating of 1.5 v and it provides a total of 60 ma-hr down to a cutoff of 1.3 v. Top recommended average current drain is 60 ma or less.

The energizer is designed to withstand shock, vibration, and acceler-



ation, and is gold-plated for good electrical contact. It employs the standard dry-battery ingredients, but in a highly refined form. The case is positive and the zinc electrode is negative.

For comparison with other power sources, the new energizer could be rated 0.1-whr. It will produce ½-hp for one second.

Structural drafting is the subject of a proposed American Standard currently being circulated for criticism and comment. The proposed standard is section 14 of the American Drafting Standards Manual. Structure, according to the standard, is an assembly of fixed

FACTS

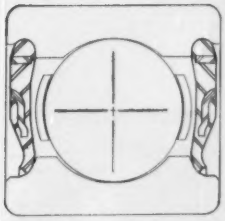
about

NEW DEPARTURE BALL BEARINGS

with

SENTRI-SEAL

on guard against dirt and wear!



The diagram shows in section the New Departure Sentri-Seal. Lip-contacting surfaces are form-ground simultaneously with the ball race, giving an extremely high degree of concentricity between sealing surfaces and the raceway.

The unique design of the Sentri-Seal gives optimum protection against dirt, and includes a number of other major advantages.

Sentri-Seals can be removed, easily replaced. As the seal is of synthetic rubber in which two metal rings are embedded, a constant-rate spring is created between the rings. Inherent flexibility prevents distortion of the bearing outer ring due to seal insertion, permitting the use of bearings to the higher accuracy specifications. The spring action maintains an efficient sealing contact with the bearing ring to bar dirt and retain lubricant. Sentri-Seals are relatively inert to oils and greases and operate satisfactorily through a temperature range of −40°F. to 225°F. Specifications available for still higher temperatures. In applications where relubrication is desired, it is easily accomplished by the injection method.

SEE "WIDE WIDE WORLD" SUNDAYS—NBC-TV

Sentri-Seal is available for a range of sizes in single-row, standard-width bearings and also in two types of New Departure adapter bearings. Sizes, dimensions and capacities are listed in the latest New Departure catalog.

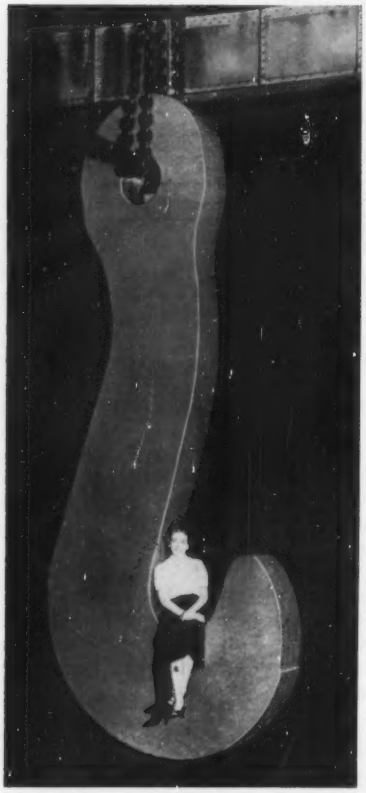
Write for full details on Sentri-Seal

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

parts which support or enclose a machine, or which constitute a composite permanent subassembly of a piece of mechanical or electrical equipment. The standard covers terminology and symbols for riveting, welding, brazing and soldering. It also covers designations for materials, heat treatment and commerical structural shapes. Free copies of the proposed standard can be obtained from Frank Philippbar, Standards Dept., American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.

POD CARRIER is now seen to be one of the functions of the Convair B-58 Hustler. Here, for the first time, underslung cargo is shown on the first U.S. supersonic bomber. Hustler has been given stilt-like landing gear especially to accommodate detachable pods. Variety of these attachments enables the B-58 to perform a corresponding variety of missions.



BIG ONES WON'T GET AWAY —big batches of molten steel, that is. This is one of two hooks for the world's largest ladle crane, capacity 500 tons, built by Morgan Engineering Co. for an eastern steel mill. The new crane weighs 1,841,000 lb without cradle and hot metal. It is driven by 11 electric motors of 1658 total hp, and it carries 1 2/3 miles of steel cable. Operator's cage, which also encloses automatic control apparatus, is as big as a five-room house.

MORTAR SPOTTER, designated AN/MPQ-4, uses radar and a portable computer to trace mortar projectiles back to their source. Experimental model developed at Army Signal Corps Laboratory has longer range than any known mortar. It is more compact than Korean-war spotter, and faster-operating due to use of new beam technique. From radar observations of mortar shell in characteristic high-trajectory flight, computer rapidly calculates location of the source of the fire. For safety of operators, the console can be set up 150 yd from the main equipment.

TORRINGTON *SPHERICAL ROLLER* BEARINGS

This bearing can take thrust, too!

Design is the secret. TORRINGTON Spherical Roller Bearings are made with an integral center flange on the inner race. This assures *positive radial stability and accurate positioning of rollers* wherever high radial load and heavy thrust are encountered under conditions of misalignment.

From crushers to cranes, power shovels to pulverizers, you get long, maintenance-free operation, better performance in your equipment, more value from your bearing dollar when you specify these rugged dependable bearings.

Prove to yourself that TORRINGTON design does make a difference. Next time specify TORRINGTON Spherical Roller Bearings. They're available with either straight or tapered bore, for shaft or adapter mounting.

THE TORRINGTON COMPANY

South Bend 21, Ind. • Torrington, Conn.

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TORRINGTON BEARINGS

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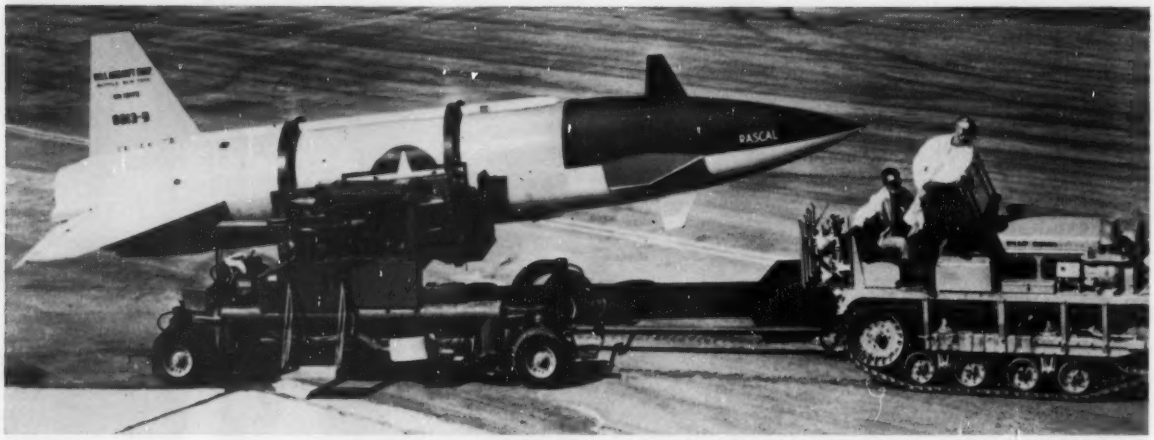


AIR FORCE RASCAL, formally designated GAM-63, is this long-range, rocket-powered, guided missile designed for air-to-surface use. Bombers carry Rascal to high altitude release point. From there it travels alone at supersonic speed to target, miles distant, while carrier returns home. Bell Aircraft is prime contractor for the Rascal weapons system, including handling and loading carriage, shown, guidance system and engine.

New Tungsten Alloys Seen for High-Temperature Applications

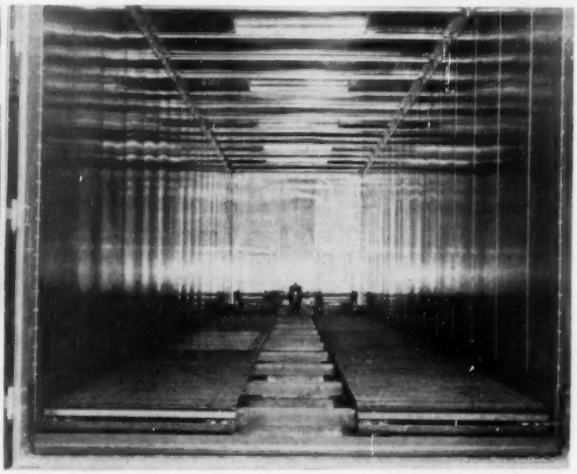
Jet Aircraft to Need More Refractory Transition Metals

NEW ORLEANS, LA.—New high-temperature alloys must be developed if current trends toward higher operating temperatures are to be maintained in many fields of technology. This was the recent observation of R. H. Thielemann, chairman, Dept. of Metallurgy, Stanford Research Institute. The new materials must be far better than any known today, he said, and tungsten-base alloys may be the answer.

The situation with regard to materials is particularly critical due to requirements in the fields of nuclear power and gas turbine engines for jet aircraft. In these applications, materials must operate in the temperature range of 1000 F to 2500 F.

Mr. Thielemann emphasized that superalloys to meet the new requirements must have oxidation resistance and strength beyond 1650 F. Alloys now in extensive use become marginal risks and metallurgically unstable at temperatures above 1650 F.

Eighteen metals have higher melting points than those of iron, nickel and cobalt. Of these, only four have significantly higher melting points and are available in sufficient quantities to be considered for the applications intended. These four are the refractory transition metals—columbium, molybdenum, tantalum and



LIVE-BOTTOM TRAILER LINER, key equipment in Trailer-Bak transport system, speeds up shipment of 6-oz size cans from fabricator to fruit juice concentrate plant. Removable, reusable liner is jumble-loaded, then slid into truck and out again at destination. Liner may also be loaded, while in the trailer, through hatches in truck roof. Slatted Link-Belt conveyor, right, travels at 12.8 fpm to form gentle moving platform and liner bottom. The "live bottom" stands 8-1/6-in. high except for motor, can be removed readily to convert trailer to conventional transporter.

tungsten. All four may prove to be important in developing alloys for service at temperatures above 1800 F, but tungsten, he said, appears to hold the most promise. This is due to its high melting point, high modulus of elasticity and high recrystallization temperature.

According to Mr. Thielemann, there are good future possibilities for tungsten, both as an alloying addition and as a base material. There is a sufficient supply of tungsten to justify its use in fairly substantial applications, and tungsten is relatively inexpensive compared to several of the new structural metals.

The development of new high-temperature alloys based on the high melting point refractory metals will be expensive, and there will be many difficult problems to solve, but the stakes are high. A suitable turbine blade material for jet engines would not only permit increased performance and efficiency but would be valuable from the standpoint of blade replacement cost alone.

Fourth Mechanisms Conference Now Scheduled for October

CLEVELAND, O. — Dates for the Fourth Mechanisms Conference announced in MACHINE DESIGN two weeks ago have been changed from May 16 and 17, to Monday and Tuesday, October 14 and 15.

The Conference planners find their original dates too close to the 1957 Design Engineering Show and Conference in New York's Coliseum, May 20—23. The change is intended to give more designers and engineers the opportunity to attend both functions.

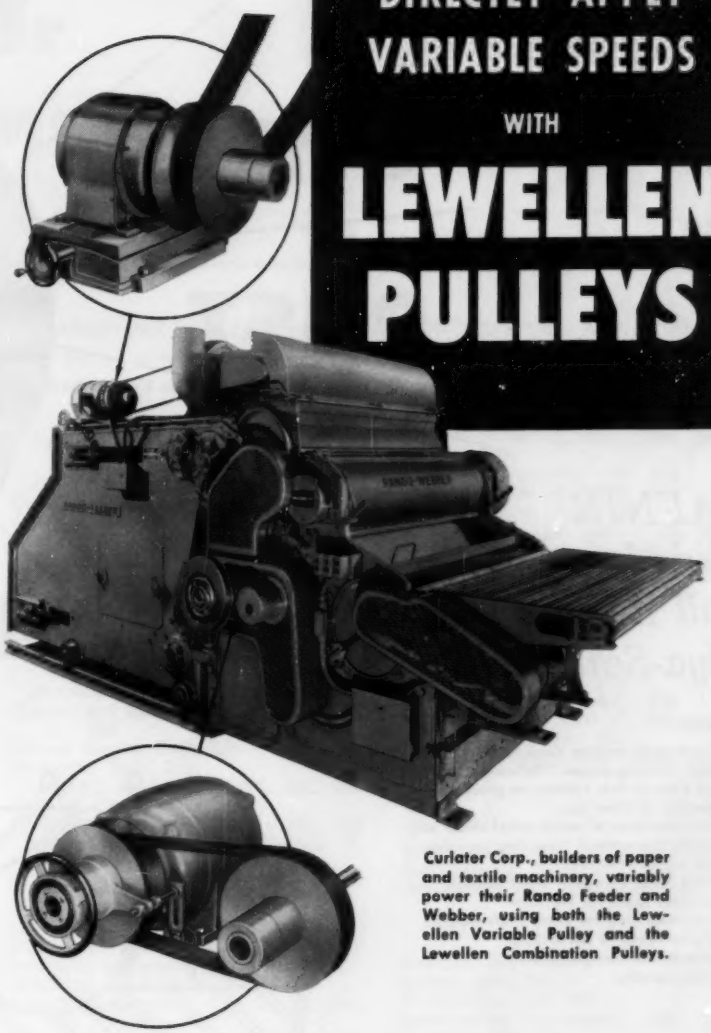
Rising Starter Rates To Fix Experienced Engineers' Raises

"Them As Has, Gits" Also Sought by Aircraft Union

SEATTLE, WASH.—Salary increases for experienced engineers at Boeing Airplane Co. will be established by the free market price for be-

(Continued on Page 22)

DIRECTLY APPLY VARIABLE SPEEDS WITH LEWELLEN PULLEYS



Curlator Corp., builders of paper and textile machinery, variably power their Rando Feeder and Webber, using both the Lewellen Variable Pulley and the Lewellen Combination Pulleys.

Lewellen Pulleys mount at motor and machine shafts—directly connect—variably power the equipment.

Handwheel provides infinitely adjustable operating speeds.

Lewellen Pulleys, applied singly or in pairs, offer wide selection of operating speeds and center distances, in ratings to 15 h.p.

Lewellen Pulleys are versatile power components—perform smoothly and dependably—operate in any position—require no supporting brackets—impose no thrust loads on motor or machine shafts—include convenient controls and accessories.

WRITE FOR CATALOG NO. 60B

LEWELLEN MANUFACTURING CO., COLUMBUS, IND.

Distributors In All Industrial Areas • In Canada—Peerless Engineering Sales Ltd., Toronto-Montreal

BEST PROTECTION YET
for Ball Bearings
exposed to

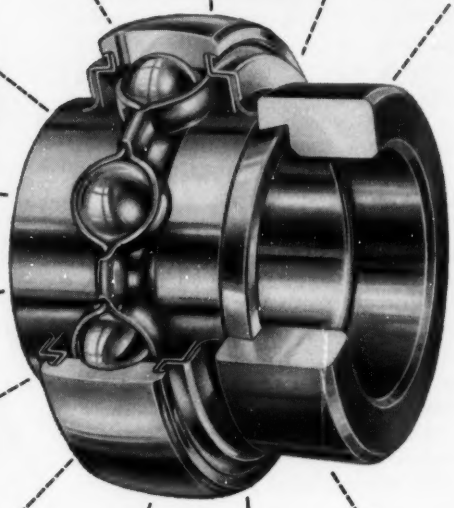
WATER

STEAM

DUST

LINT

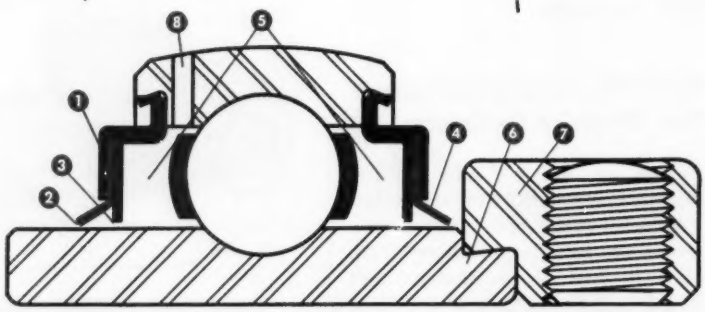
DIRT



FAFNIR
Wide Inner Ring
Ball Bearings with
Plya-Seals (contact type)

FEATURES

1. Plya-Seal of resilient Buna N rubber-coated fabric insuring proper "follow-up" contact
2. Seal rides in firm contact on ground outside diameter of inner ring
3. Close-clearance of inside metal shield with outside diameter of inner ring provides rigid support for seal
4. Flared lip of Plya-Seal won't push in
5. Generous space for lubricant
6. Wide inner ring for extra shaft support
7. Fafnir-originated self-locking, eccentric-cam-design collar
8. Relubricatable



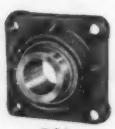
On slow to moderate speed applications where service conditions are subject to excessive contamination, Fafnir Plya-Seal equipped Wide Inner Ring Ball Bearings fill a definite need. Their laboratory and field-tested performance offers the proven protection of contact-type Plya-Seals. They provide every advantage of Fafnir Wide Inner Ring Ball Bearings with Self-Locking Collars . . . ease of application, positive locking, extra large support area on the shaft, relubricatable or nonrelubricatable, self-alignments.

The Plya-Seal as incorporated in the Fafnir Wide Inner Ring Bearing consists of two steel plates between which is sandwiched a synthetic rubber-coated fabric sealing washer. Both steel plates are fixed securely in an outer ring groove. The inner plate provides a rigid backing for the seal and a close-clearance baffle for the retention of grease.

This recent addition to the Fafnir Line is dimensionally interchangeable with the Fafnir Wide Inner Ring Ball Bearings equipped with Mechani-Seals. All types are prelubricated at the factory. Write for descriptive bulletin. The Fafnir Bearing Company, New Britain, Connecticut.

FAFNIR WIDE INNER RING BALL BEARING WITH PLYA-SEALS AVAILABLE IN UNITS BELOW

RAK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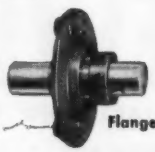
Flangette

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

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MACHINE DESIGN
READER SERVICE

Reader Information Service

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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Ratio Plotter	790
Laboratory Furnace	791
Pressure Transmitter	792
Miniature Control Unit	793
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MACHINE DESIGN
MAR. 21, 1957

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426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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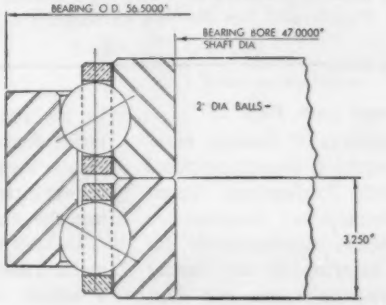
Here are the bearings that "couldn't be built"... *as produced by Kaydon*

THE manufacturer who wanted these bearings had been told they "couldn't be built." Or at least that's what he'd been told *until* he contacted **KAYDON**. What he required was a bearing 56½" in diameter combining high capacity, and exceptional precision for concentricity and face runout that would fit in limited space.

KAYDON designed a double-row angular contact ball bearing (see sketch at right). Actual tests have proved that the bearing fulfills every requirement.

If your designs require bearings of exceptional capacity, close-tolerance precision and/or very thin section — it will pay you to contact **KAYDON** of Muskegon. **KAYDON** has a long-standing reputation for accomplishing the near impossible.

CROSS SECTION — *The bearing that couldn't be built*



Just Out! Get your copy of the new **KAYDON** *Reali-Slim thin bearing catalog No. 54.*

THE KAYDON ENGINEERING CORP.

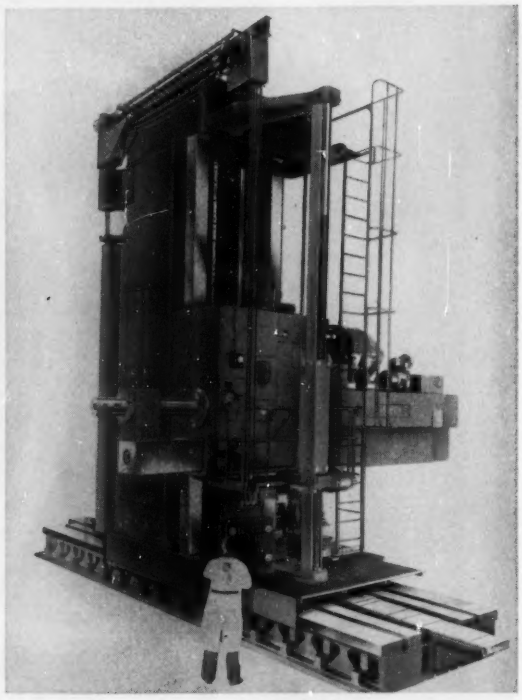
MUSKEGON • MICHIGAN

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

K543

PRECISION BALL AND ROLLER BEARINGS

ACCURATE POSITIONING, within 0.0001-in. or 5 seconds of arc, is claimed for this numerical control system developed by Pratt & Whitney Co. for its jig borers, vertical hole grinders and rotary tables. P&W Electrolimit measuring system assures the stated accuracy. Machine operations are controlled by punched paper tape in which decimal data are posted directly, without "translation" required by systems based on binary numbers. Tape reader in the P&W system uses pneumatic sensing. Air is forced through the tape holes to an enlarged chamber fitted with a neoprene diaphragm which in turn operates limit switches. To assure accuracy of spacing in the tape, data is punched in while tape moves at uniform speed. Punch unit has moving carriage.



LARGEST, MOST VERSATILE of type is claimed for this floor-type horizontal boring, drilling and milling machine recently announced by Giddings & Lewis Machine Tool Co. It weighs 200 tons, is 27 ft high, has spindles of 10, 12 or 14-in. diam. Under-arm box beam, 18-in. square, mounts heavy accessories like 2-ton 90-degree angular miller. Welded column of corrugated rib construction supports 42-ton headstock. Speed drive gears and helical bull gear in the headstock can transmit 15 hp per revolution. Milling feeds to the column and headstock vary from 0.5-in. to 120 in. per minute over four gear ranges.

(*Continued from Page* 15)

ginning engineers if Boeing management accepts a recent proposal of the Seattle Professional Engineering Employees Association. The plan would automatically increase the salaries of all Boeing engineers by the same per cent that salaries accepted by beginning engineers had increased during the last year. This would eliminate salary "leveling" for all Boeing engineers.

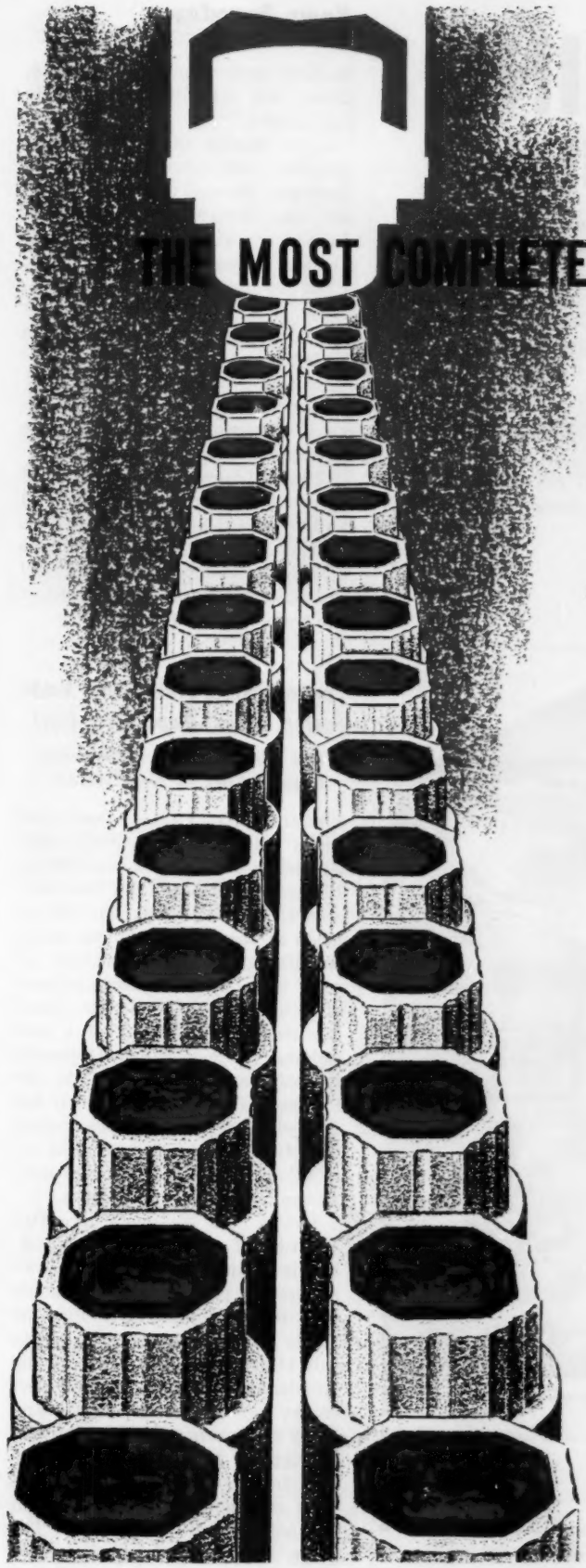
Salary "leveling" occurs when a company raises its hiring salaries for beginning engineers without proportionally increasing the salaries of its experienced engineers. The new plan may be the first proposal of its kind to be made to an employer of engineers. A novel feature is that the Association's members will be asked to approve the contract without knowing the amount of increase.

In addition to the plan for automatic raises, the Association seeks a salary unleveling increase and the establishment of a Professional Experience Register. The salary unleveling increase would result in a higher percentage increase for the higher salaried engineers.

The Professional Experience Register would be created by making a detailed inventory of the experience, capabilities, and preferences of Boeing engineers. Whenever the company required an engineer for a particular job, a search of the Register would reveal those having the necessary qualifications. The engineer finally assigned the job would be selected on an individual basis as at present. The Register would simply provide a means to insure that no qualified engineer is overlooked.

Range Test Radar System Tracks Missiles, Plots Course

NEW YORK, N. Y.—A new instrumentation radar system developed by RCA now makes possible direct calibration and immediate evaluation of the performance and behavior pattern of guided missiles. The system can also be assigned



THE MOST COMPLETE LINE OF LEADED STEELS

Copperweld offers the most complete line of leaded alloy and carbon steels available today. Leaded steels give you faster feeds and speeds, saving of tool costs, and finer finishes that often eliminate a final machining operation. Here's a partial list of some of the most popular leaded steels available through Copperweld:

Ledloy*A	A-4142	A-5140
C-1040	A-4145	A-5150
C-1041	A-4147	A-8620
C-1045	A-4150	A-8622
C-1050	A-4620	A-8640
C-1137	A-4640	A-8642
C-1141	A-4720	A-8645
C-1146	A-5046	A-8647
C-1153	A-5117	A-8650
A-4140	A-5120	E-52100

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Circle 414 on page 19

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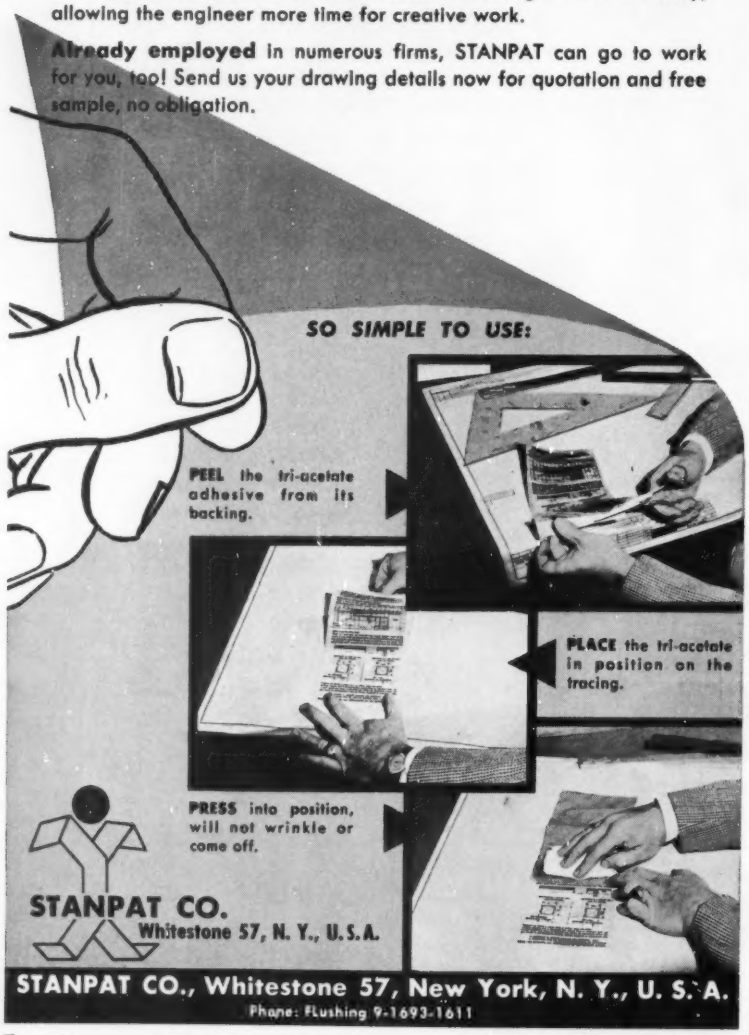
His name is STANPAT, and though he is not human he can swallow up your tedious re-drawing and re-lettering of standard and repetitive blueprint items for 24 hours a day if need be — without tiring. STANPAT is the remarkable tri-acetate sheet that is pre-printed with your specification and revision boxes, standard symbols, sub-assemblies, components and cross-sections . . . with adhesive front or back, waiting to be pressed into position in 15 seconds! Reproductions are unusually crisp and clear, guaranteed not to wrinkle, dry out or come off. STANPAT saves hundreds of hours in drafting time and money, allowing the engineer more time for creative work.

Already employed in numerous firms, STANPAT can go to work for you, too! Send us your drawing details now for quotation and free sample, no obligation.


SO SIMPLE TO USE:
PEEL the tri-acetate adhesive from its backing.
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to plot performance of satellite, drone, and other free-space moving targets.

It is capable of tracking with accuracy over extended ranges, in darkness, through clouds, and under any atmospheric conditions. Data accumulated can be reduced almost instantly to final form. Prior to the RCA development, these data had been obtained by optical devices, radio triangulation systems, and modified radar equipment. Moreover, the data reduction methods dictated by these devices characteristically require months for computation.

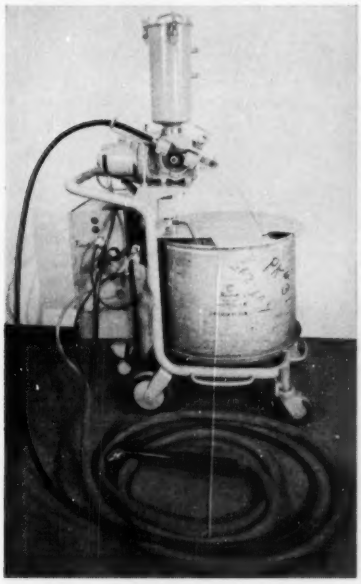
The instrumentation radar will be used to track targets with and without beacons and to produce spherical co-ordinate data outputs of high accuracy. This data will provide an instantaneous record of the trajectory of the targets.

Common Steel Welds Now Made Faster, Across Gaps, Over Rust

Gas Stream Shields Electrode, Carries Flux in New Welder

PHILADELPHIA, PA. — Downhand welds with bare, common steel electrodes can now be made 50 to 100 per cent faster than with covered electrodes. Welds can also be made across gaps and along seams containing moderate amounts of rust, scale, and moisture without affecting the weld soundness. These are claimed capabilities of a new welding process, called Unionarc, recently announced by Linde Air Products Co. A continuously-fed wire electrode magnetically coated with flux and shielded in a gas atmosphere is a feature of the new, manual, arc welding process.

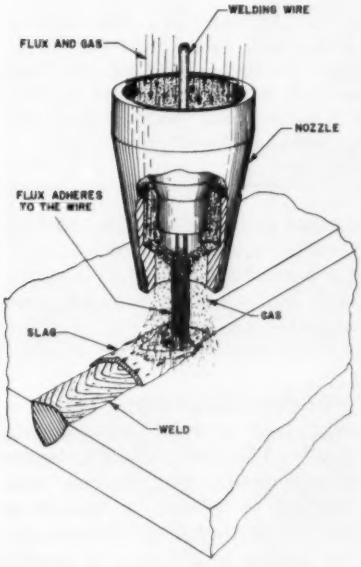
In Unionarc welding, a bare wire electrode of common steel composition is continuously fed from a 300-lb capacity pack through a flexible tube to the torch. The operator starts and continues welding to suit his requirements. There is no frequent stopping to change electrodes nor a series of starts and stops in making a joint. The wire is supplied in a Pay-Off-Pak covered to keep the wire clean. The pack is supported and rotated on a motor-driven turntable. The table is controlled so that wire



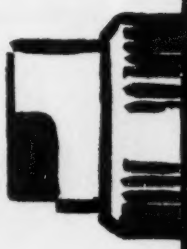
Unionarc UAW-1 torch, inside the coil above, is rated 450 amp continuous duty. The welding machine carries wire coiled in Pay-Off-Paks, welding powder dispenser, gas regulator, hose, motor to operate the process, and process controls.

tension at the feed rolls is minimized. The large wire pack provides one week's supply.

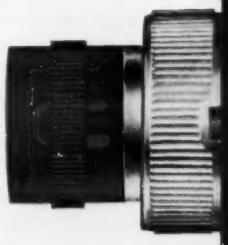
Specially compounded magnetiz-



Welding wire in the Unionarc process is fed continuously to the weld and is surrounded there by special, magnetizable flux carried by the gas.



This space free for other controls when Push-Lite is used.



NEW PUSH-LITE* SAVES HALF THE SPACE AND REDUCES COST

Using both a pushbutton and indicating light on one operation will soon be old-fashioned. In fact, it's a waste of money and space because one new Push-Lite unit will do both jobs.

The new unique Push-Lite with its button-shaped plastic lens combines the functions of both a pushbutton and indicating light. One push transmits the appropriate signal and, at the same time, energizes the indicating lamp.

Push-Lites are liquid-tight as are other operators and lights in the Westinghouse Oil-Tite* pushbutton line. Precision-machined fits and neoprene seals will not allow liquids to reach electrical parts.

For more information about Oil-Tite pushbuttons ask for the new booklet (B-7022) or the 72-page Pushbutton Guide (B-6749), a catalog of all Westinghouse pushbuttons. Write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Penna. or call your local Westinghouse distributor.

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Circle 416 on page 19

Earth Satellite's Magnesium Shell—

International News Photos

—typical of B & P's Skill in Fabrication

To a skin of non-uniform thickness of 0.015" to 0.030", interior bracing must be welded or secured with screws. Weight-savings of fractions of ounces can be highly important. The outside, manufactured to a tolerance of four micro-inches, must be polished to an intense mirror brightness.

Magnesium was chosen for the structural material. B&P was chosen to work out the complexities of the fabricating and finishing operations and build the spheres . . . Whenever you are faced with a difficult or delicate operation-problem in Magnesium or Titanium, a talk with B&P engineers is well worth while.

Engineering Facilities in Detroit and Los Angeles

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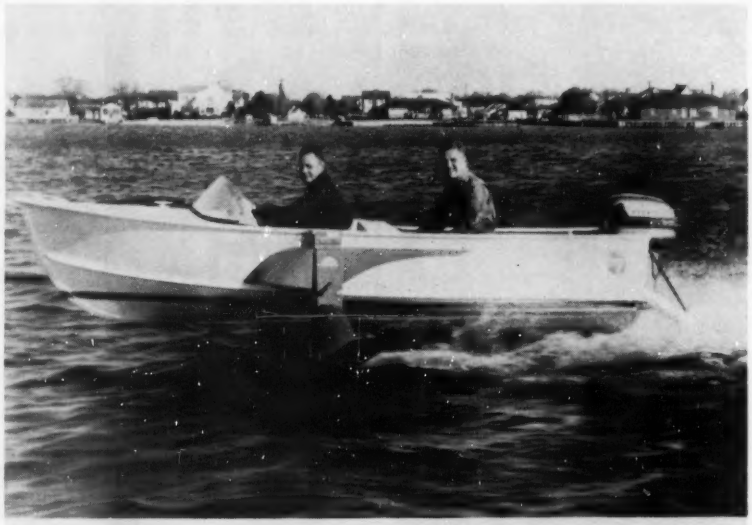
Circle 417 on page 19



RETRACTABLE HYDROFOILS lift this 15½-ft boat out of the water at 15 mph. On the hydrofoils, boat speed is doubled. At 30 mph, the hydrofoils carry 850 lb in addition to more than 500 lb for the boat. For land transport, hydrofoils swing into the boat. First boat thus equipped is Runabout by Gruman Boats Inc. Dynamic Developments Inc. designed the hydrofoils, made them of Bakelite epoxy resin, glass-cloth reinforced.

able flux is placed in a dispenser and fed from this point through a flexible tube to the torch. The dispenser is designed to measure exactly the amount of flux in proportion to the amount of wire that is being fed. The dispenser can be adjusted to feed different flux-to-wire ratios, but the usual ratio is between ⅜ to ½ lb of flux per lb of wire. This predetermined ratio is automatically maintained regardless of the rate of wire feed.

The magnetic field created by the electric current passing through the wire magnetizes and attracts the flux to the wire. The welding current is supplied by a direct current power source. A constant potential rectifier can be used with the added advantage of assuring easy and uniform starting and control of arc length.

Engineering graphics is now a recognized field of postgraduate study. The first master's degree in engineering graphics has been awarded to Edward V. Mochel at Illinois Institute of Technology. The degree is designed to qualify teachers in the subject at college level. The curriculum is based on a background in drawing, basic science, engineering and educa-

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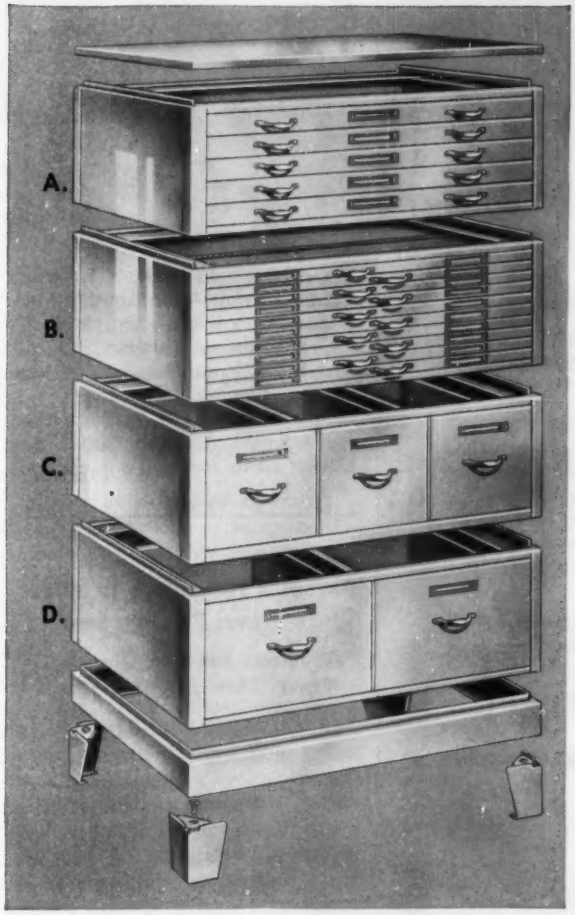
Right Now Is the Time to Eliminate Haphazard Filing, Save Time and Space with a Hamilton UnitSystem!



The boom in production means more pressure for drafting room output . . . more pressure on you for filing time and space. Right now is the time to replace those old, inadequate files you've been putting up with—now's the time to get a modern Hamilton UnitSystem from Bruning.

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One unit (A) has five deep drawers to provide ideal storage for semi-active or inactive drawings and records. Shallow-Drawer Unit (B) with special tracing lifters makes any active tracing easily accessible without risk of damage to companion tracings. Vertical Filing Units (C-D) with index binders and compressors keep active small sheets upright without wrinkling.

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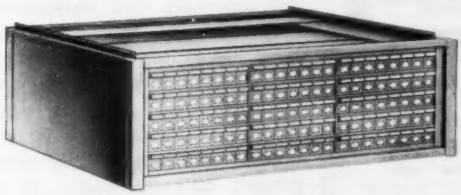

File units for roll tracings are available. Individual trays protect each roll from dirt, tearing, and crushing.

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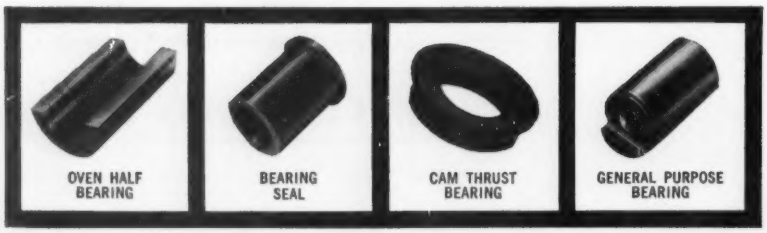

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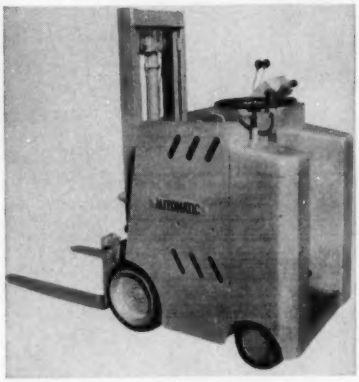
tion. At the present, Illinois Tech is the only school offering the degree. A similar program at Illinois leads to a B.S. in engineering graphics and is intended to qualify graphics teachers at the high school level.



STUBBIER LIFTER, Automatic Transportation Company's revised Docker, is now 6 in. shorter due to use of thinner batteries. Overall length is 47⅝ in. from heel of forks to end. Turning radius is 49½ in.; lifting height, 135 in.; traveling speed, 5 mph. A 6-ft operator on the Docker clears standard box-car door.

Air Arms Technology to Make Space Travel Possible Soon

Problems Are Man, Himself; Travel Through Atmospheres

SAN DIEGO, CALIF.—Trips to the moon, and beyond, are no longer the exclusive province of science fiction. Serious consideration of such flights is well under way. This was evident at the first National Symposium on Space Flight attended recently by more than 300 scientists and engineers.

One session was addressed by Maj. Gen. Bernard A. Shriever, commander, Western Development Div., ARDC, USAF. Gen. Shriever revealed the extent to which the accomplishments in current defense project will be useful in space technology.

"The same propulsive unit that boosts a heavy nose cone-warhead to 25,000 ft/sec, could boost a

somewhat lighter body to the escape velocity of 35,000 ft/sec or to an orbital path around the earth . . . . The same guidance system that enables the warhead of a ballistic missile to reach its target within a permissible accuracy would also be sufficiently accurate to hit a target much smaller than the moon . . . . These same propulsive and guidance components could also be used for surface-to-surface transport vehicles of various sorts. I would guess that 90 per cent of the *unmanned* follow-on projects that one could visualize for the future can be undertaken with propulsive guidance, and structural techniques, *presently under development.*

"It will not be too difficult to extend these present developments to . . . space travel of personnel. However, . . . a tremendous amount of human factors research will be necessary. A specific example . . . is sustained thrust through space.

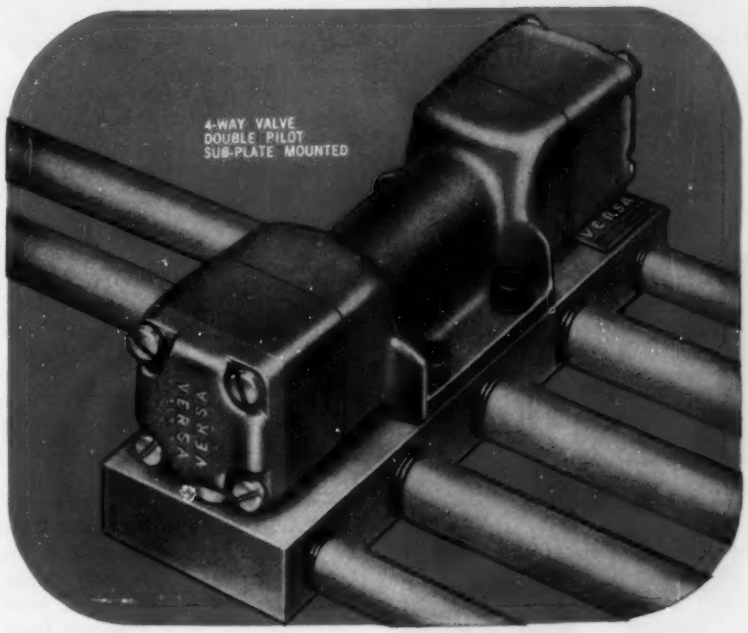
"Perhaps . . . for all time, space technology will include as its most characteristic problem the need for going from the surface of one terrestial body to another with successful passage through the atmosphere of each.

"A word is necessary on the relationship between military need and scientific feasibility in space technology . . . . Decades from now the important battles may not be sea battles or air battles, but space battles . . . . Our prestige as world leaders might well dictate that we undertake lunar expeditions and even interplanetary flight when the appropriate technological advances have been made and the time is ripe."

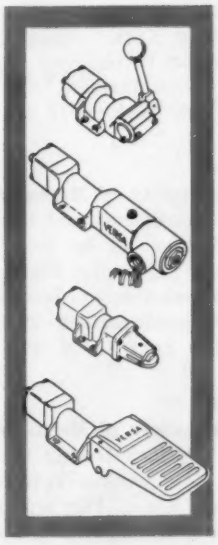
The evolution of space vehicles will be a gradual process, with the first step being the *unmanned,* artificial earth satellite and then perhaps unmanned exploratory flights to the moon or Mars. These flights would gather scientific data and accumulate information on space environmental conditions. The information will lead to a better understanding of our own planet, particularly the movements of polar air masses, the course of jet streams and the earth's magnetic field.

Payload capability of a future

FOR MAXIMUM CAPACITY
IN MINIMUM SPACE . . .



THE VERSA
MANIFOLD MOUNT VALVE



The **Versa Manifold Valve** has been especially designed for use where space is at a premium.

All piping can be installed, connected to manifold plate and even purged before installation of the valve itself. The valve is then simply bolted into place on the manifold plate. The valve proper, being independent of the piping, can be easily removed for service or replacement without disconnecting piping or disassembling the valve.

Versa Control Valves are available with any type of actuating device in sizes from ⅛" to 1" NPT, in 2-, 3-, 4-, and 5-way type, and for pressures from partial vacuum to 500 PSIG.

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Circle 421 on page 19

satellite could be in the order of hundreds or even a thousand pounds. This would permit more instrumentation and many types of space experiments.

"Given vehicles with these capabilities, . . . a lunar research vehicle is highly possible. It seems certain that in the not too distant future it will be tried."

Meetings

AND EXPOSITIONS

April 2-5—

Society of Automotive Engineers Inc. Aeronautic Meeting and Production Forum and Aircraft Engineering Display to be held at the Hotel Commodore, New York. Further information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

April 4-5—

American Management Association. Research and Development Conference to be held at the Statler Hotel, New York. Additional information can be obtained from association headquarters, 1515 Broadway, New York 36, N. Y.

April 7-10—

American Society of Mechanical Engineers. Instruments and Regulators Conference to be held at Northwestern University, Chicago. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

April 8-10—

American Society of Mechanical Engineers. Spring Meeting to be held at the Hotel Dinkler-Tutwiler, Birmingham, Ala. Further information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

April 8-11—

American Management Association. National Packaging Conference and exposition to be held at the International Amphitheatre and the Palmer House, Chicago. Additional information can be obtained from association headquarters, 1515 Broadway, New York 36, N. Y.

April 9-10—

Conference on Electronics in Industry to be held at Illinois Institute of Technology, Chicago. Further information is available from conference secretary D. H. Thormahlen, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

April 9-11—

American Welding Society. Fifth Welding Show to be held at Convention Hall, Philadelphia. Annual meeting and technical sessions of the AWS will be held at the Hotel Sheraton, April 8-12. Further information can be obtained from society headquarters, 369 Lexington Ave., New York 17, N. Y.

April 11—

Association of Lift Truck and Portable Elevator Manufacturers. Spring Meeting to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from association headquarters, Suite 759, 1 Gateway Center, Pittsburgh 22, Pa.

April 15-17—

American Society of Lubrication Engineers. 12th Annual Meeting to be held at the Sheraton Cadillac Hotel, Detroit. Additional information can be obtained from society headquarters, 84 E. Randolph St., Chicago 1, Ill.

April 16-17—

American Institute of Mining, Metallurgical and Petroleum Engineers. Conference on High-Temperature Materials to be held at Hotel Carter, Cleveland. Further information is available from institute headquarters, 29 W. 39th St., New York 18, N. Y.

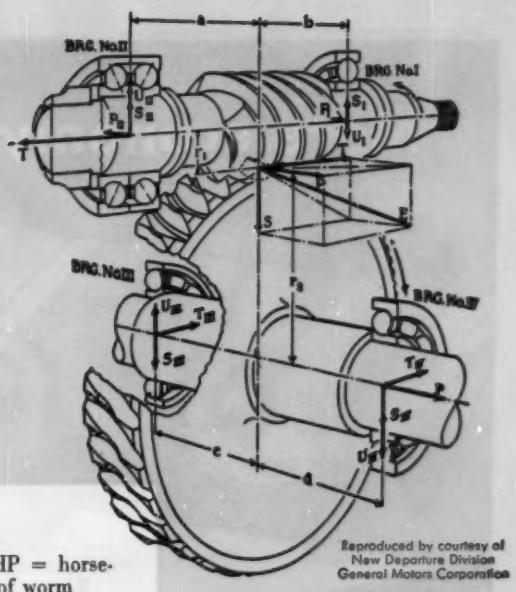
April 23-24—

American Institute of Electrical Engineers. Third Biennial Conference on Electric Heating to be held at the Commodore Perry Hotel, Toledo, O. Additional information is available from institute head-

(Advertisement)

Helpful Data from DE LAVAL

How to Calculate Worm Gear Bearing Loads



Reproduced by courtesy of New Departure Division General Motors Corporation

$Q = \dfrac{HP \times 63025}{N}$ = TORQUE INPUT to worm, lbs. inches; HP = horsepower transmitted and N = rev. per min. of worm

$P = \dfrac{Q}{r_1}$ = TANGENTIAL FORCE of worm, where

r_1 = Pitch radius of worm in inches

[r_2 = Pitch radius of worm gear

$= \dfrac{1}{2\pi}$ (number of teeth in gear x axial worm pitch)]

$S = \dfrac{P \tan \alpha}{\tan \gamma}$ = SEPARATING FORCE, where

α = Axial tooth pressure angle*

γ = Helix or lead angle of worm*

$= \tan^{-1} \dfrac{\text{lead}}{2\pi r_1}$, or $\tan^{-1} \dfrac{\text{Number of threads x axial worm pitch}}{2\pi r_1}$

$T = \dfrac{P}{\tan \gamma}$ = WORM THRUST, or tangent force driving worm gear

* LEAD ANGLE 0°-35° use 27½° Pressure Angle
LEAD ANGLE 35°-45° use 30° Pressure Angle

BEARING LOADS

Due to	on Brg. I	on Brg. II
P	$P \dfrac{a}{a+b} = P_I$	$P \dfrac{b}{a+b} = P_{II}$
S	$S \dfrac{a}{a+b} = S_I$	$S \dfrac{b}{a+b} = S_{II}$
T	$T \dfrac{r_1}{a+b} = U_I$	$T \dfrac{r_1}{a+b} = U_{II} = U_I$
Total Rad. Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{P_{II}^2 + (S_{II} + U_{II})^2} = R_{II}$
Thrust Load		T
Total Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{R_{II}^2 + T^2}$

Due to	on Brg. III	on Brg. IV
P	$P \dfrac{r_2}{c+d} = U_{III}$	$P \dfrac{r_2}{c+d} = U_{IV} = U_{III}$
S	$S \dfrac{d}{c+d} = S_{III}$	$S \dfrac{c}{c+d} = S_{IV}$
T	$T \dfrac{d}{c+d} = T_{III}$	$T \dfrac{c}{c+d} = T_{IV}$
Total Rad. Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{T_{IV}^2 + (S_{IV} + U_{IV})^2} = R_{IV}$
Thrust Load		P
Total Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{R_{IV}^2 + P^2}$

Speed Change

$$\text{Gear rpm} = N \times \frac{\text{Number of threads in worm}}{\text{Number of teeth in gear}}$$

For simplicity in bearing load computations for worm gearing, the normal tooth force E is treated in terms of its three perpendicular elements, namely, P, the tangential driving force at pitch radius of worm; S, the force tending to separate worm from the gear, due to the pressure angle; and T, the thrust produced by the lead or helix angle of the worm.

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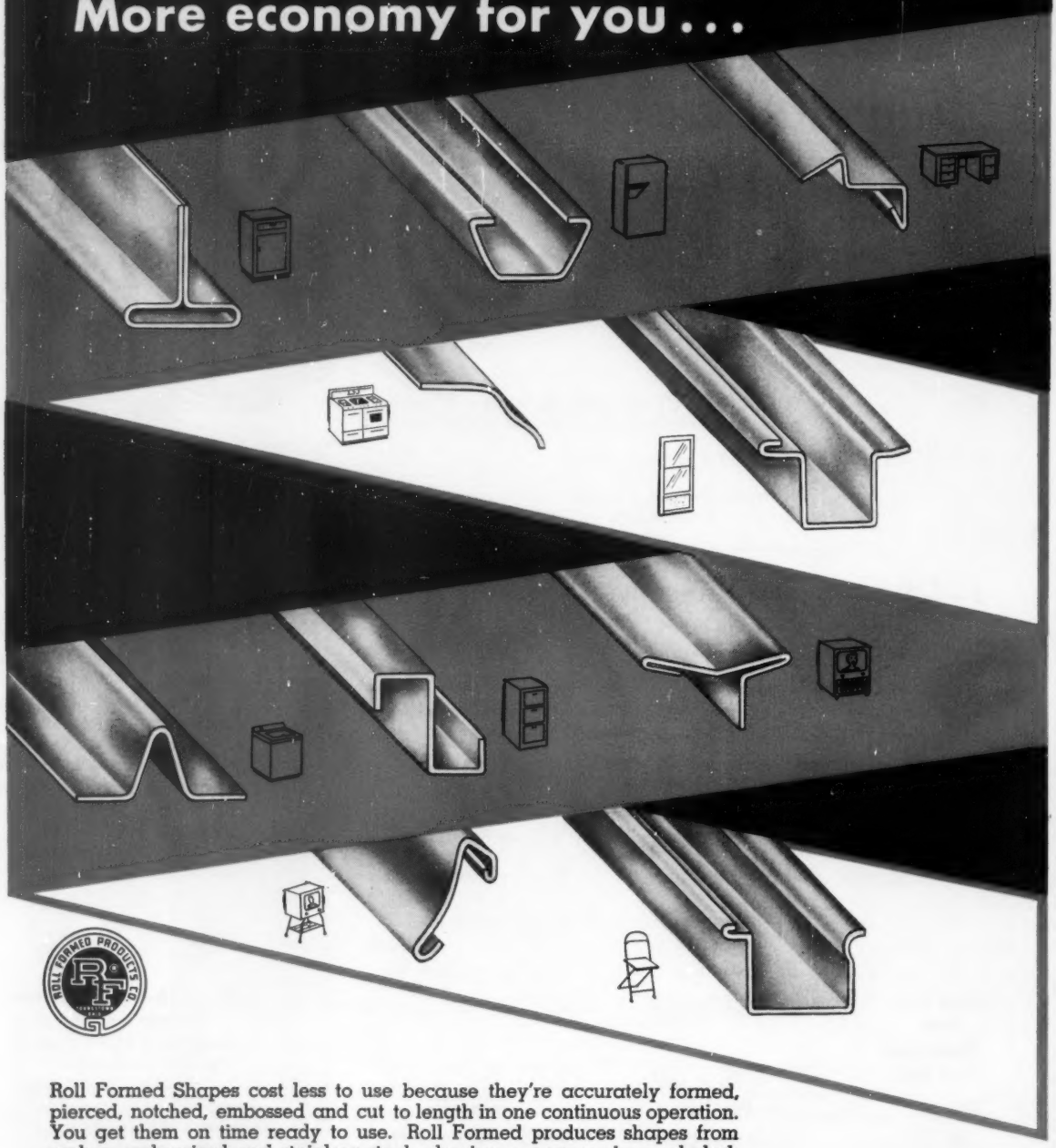

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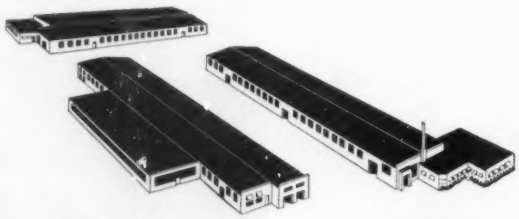

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April 25-26—

American Society of Mechanical Engineers—Society for the Advancement of Management. Management Conference to be held at the Statler Hotel, New York. Further information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

April 25-26—

American Zinc Institute Inc. 39th Annual Meeting to be held at the Drake Hotel, Chicago. Further information is available from institute headquarters, 60 E. 42nd St., New York 17, N. Y.

April 25-26—

Institute of Environmental Engineers. Annual Technical Meeting to be held at the LaSalle Hotel, Chicago. Further information is available from Henry F. Sander, Vapor Heating Corp., 6420 W. Howard St., Chicago, Ill.

April 27-May 2—

Scientific Apparatus Makers Association. 39th Annual Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Additional information is available from association headquarters, 20 N. Wacker Dr., Chicago 6, Ill.

April 29-May 3—

7th National Materials Handling Exposition to be held at Convention Hall, Philadelphia. Further information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

April 30-May 1 —

Metal Powder Association. 13th Annual Meeting and 1957 Metal Powder Show to be held at the Drake Hotel, Chicago. Further information is available from association headquarters, 130 W. 42nd St., New York 36, N. Y.

May 20-23—

Design Engineering Show to be held at the Coliseum, New York. Second Annual Design Conference, to be held in conjunction with the show, is sponsored by the Machine Design Div. of ASME. Further information on the show is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Oct. 14-15—

Fourth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

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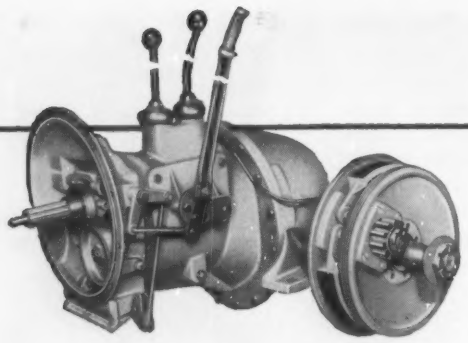

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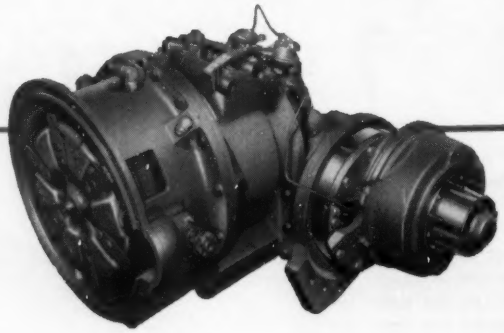

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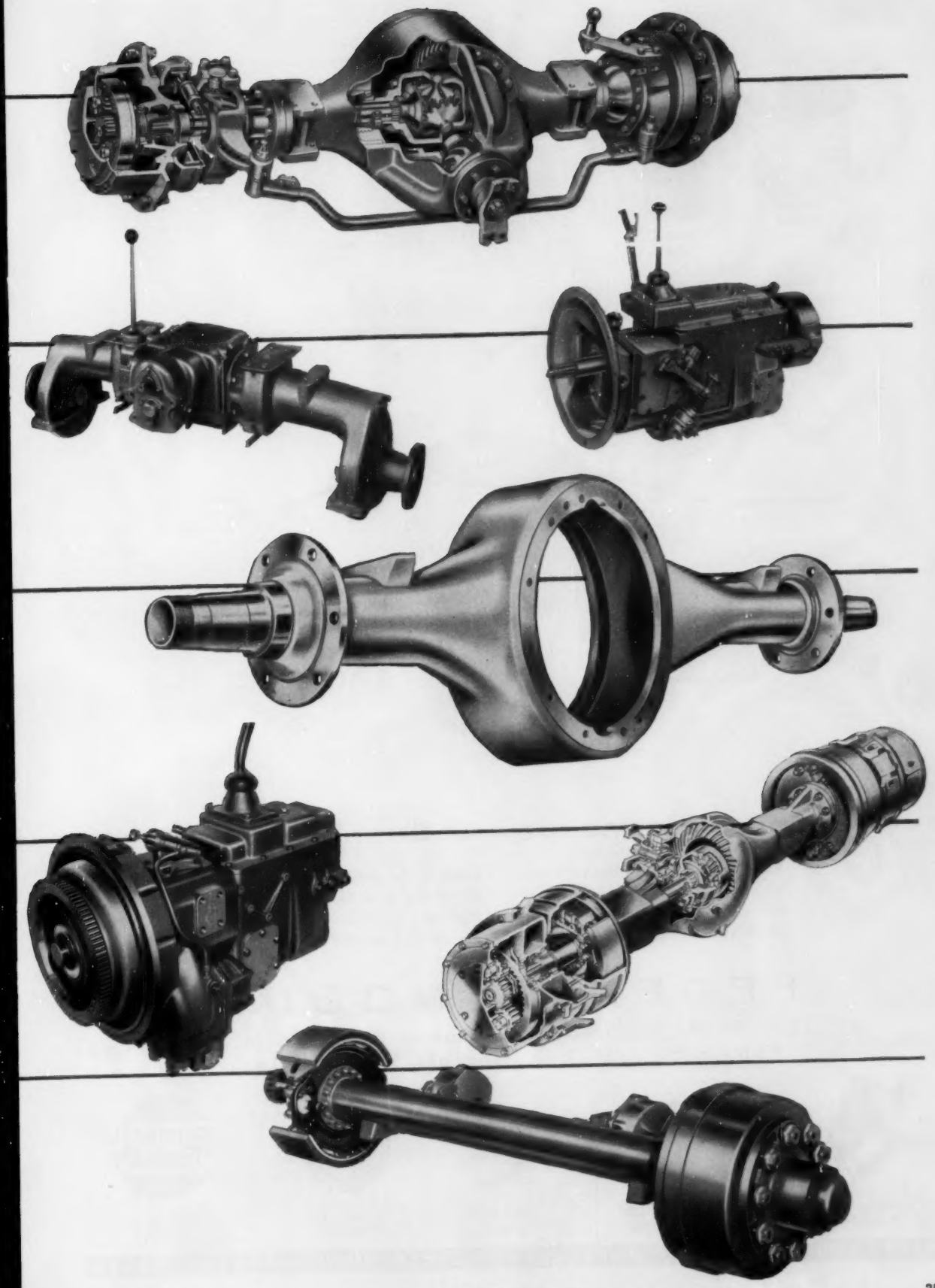

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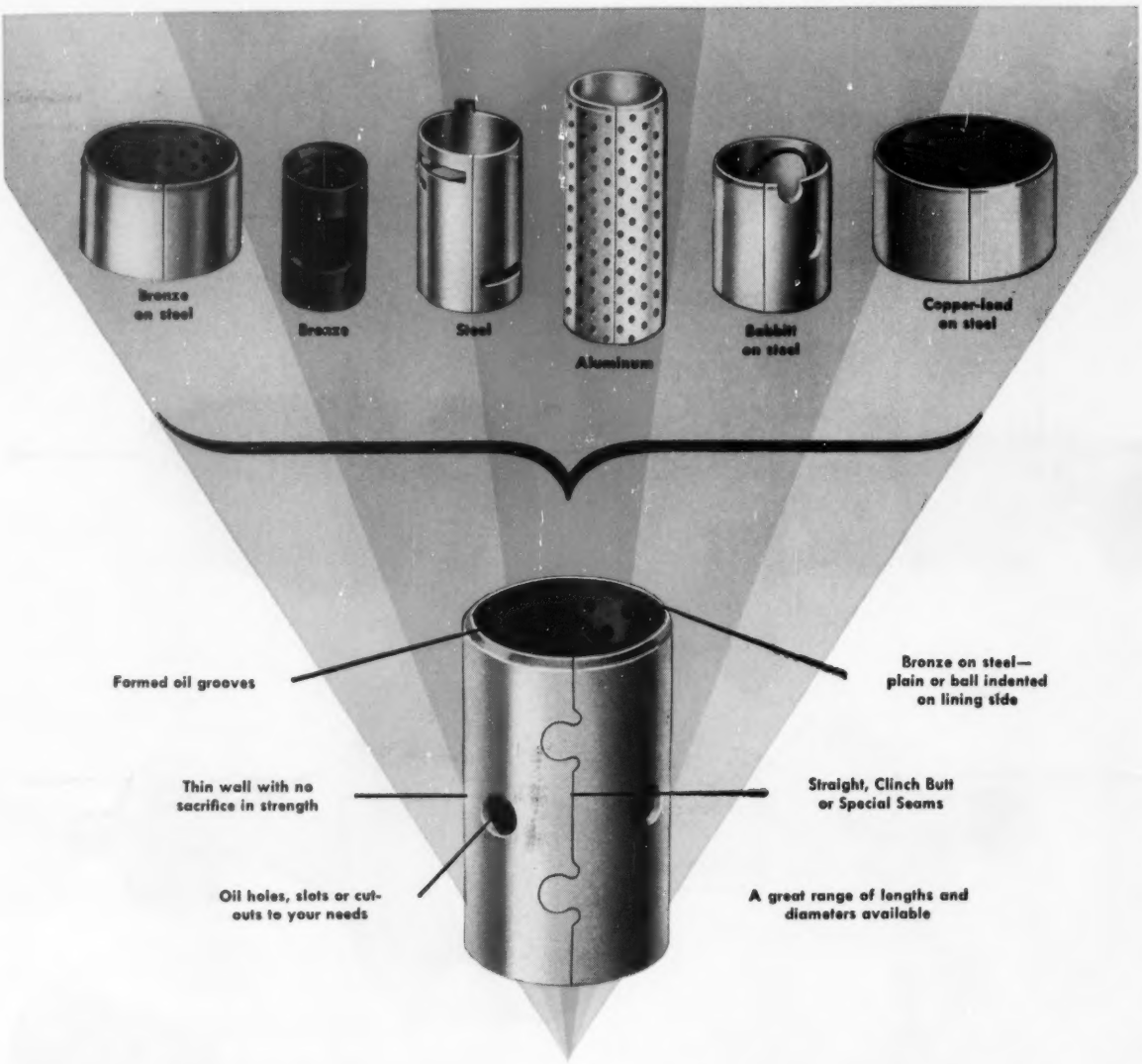
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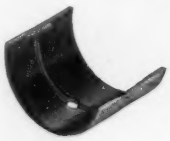

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HERE'S PROOF

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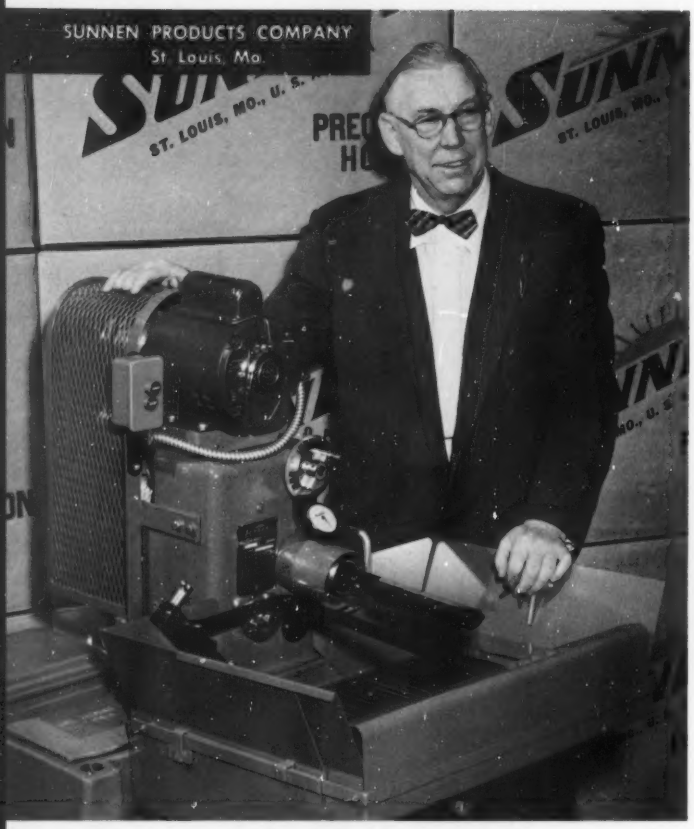

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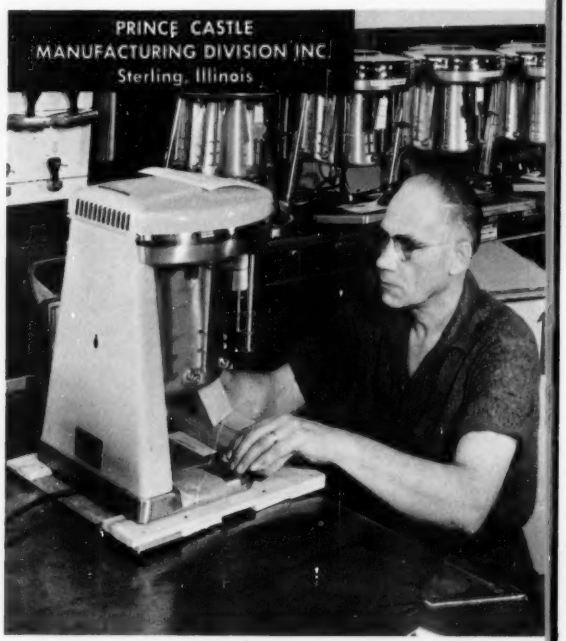
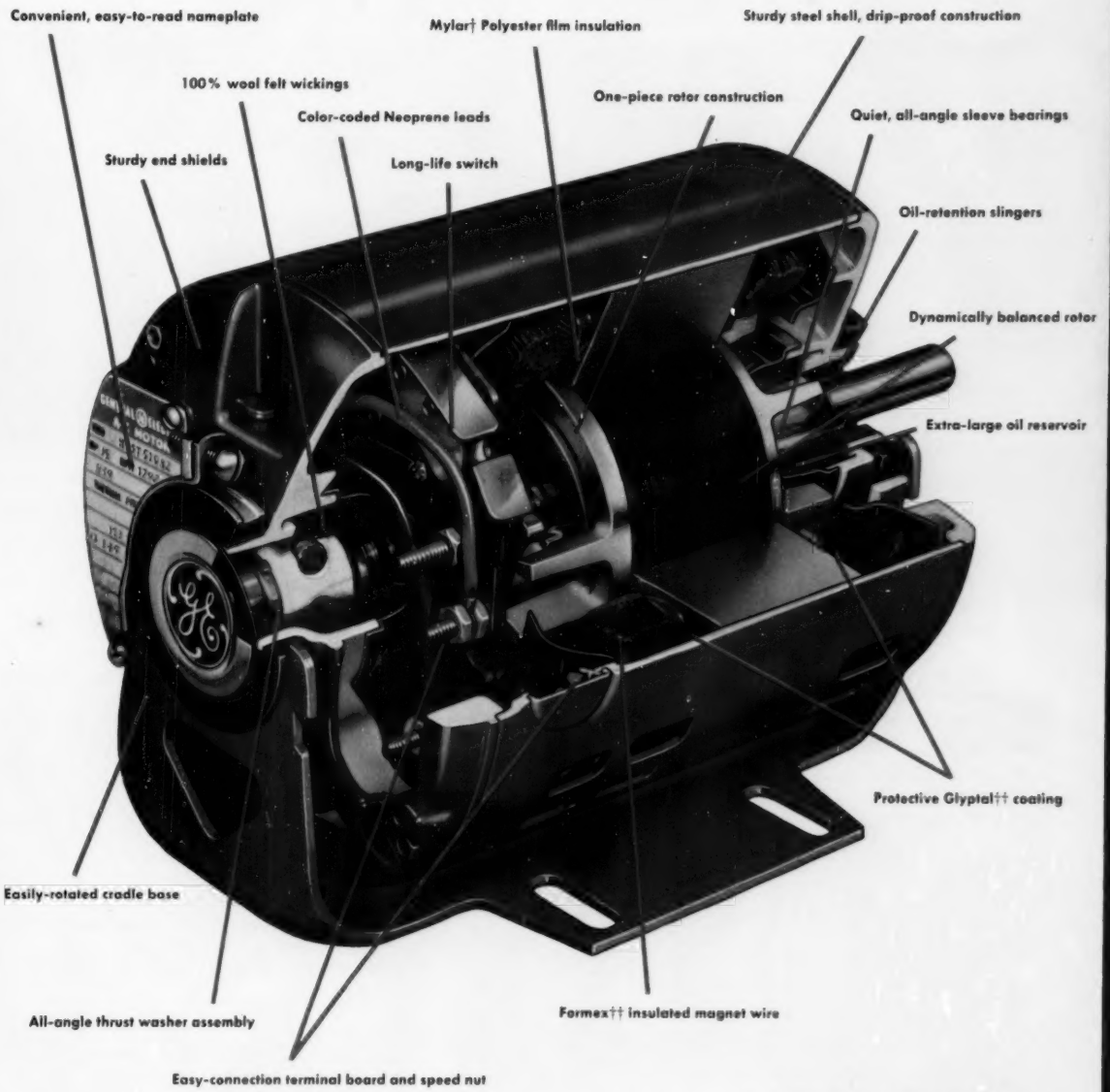


EXTRA-LONG LIFE

"G-E motors are so reliable that we've extended our motor guarantee from 1 to 5 years. Their light weight helped us cut our Multimixers about 15 lb. and their quiet operation is another big point."

The General Electric "YEARS AHEAD" motor*

The motor that set a new standard . . .



*available in both 48 and 56 frames
†Reg. trademark of Dupont Co.
††Reg. trademark of General Electric Co.

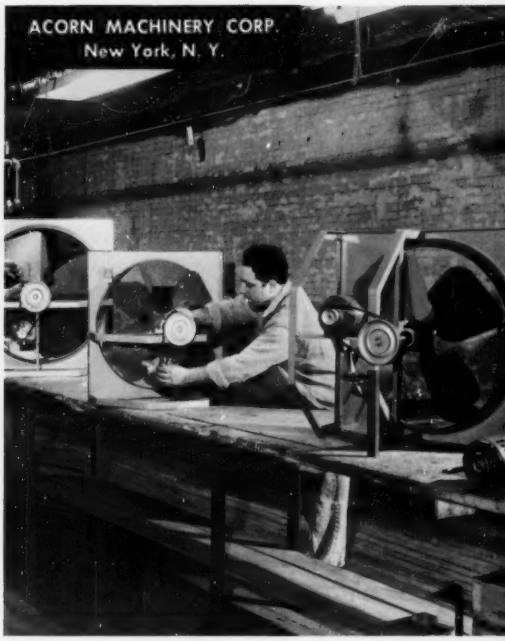
Ten manufacturers tell how they—and you—benefit with General Electric fhp motors

GENERAL ELECTRIC

—General Electric fhp motors can

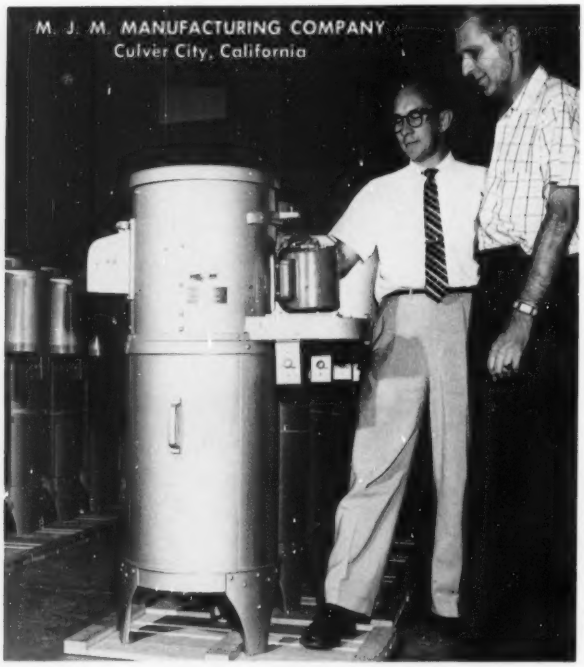
MINIMUM MAINTENANCE

"ROBOT-MATIC Door Openers require no maintenance, because the motor is permanently oiled. This feature, plus all-angle motor and Operator mounting, make them ideal for use in inaccessible places."



CUSTOMER ACCEPTANCE

"We attach the tag, 'Equipped with General Electric Motor,' to our equipment, and find it is a big extra in customer acceptance. We've also achieved a considerable weight reduction which reduces shipping costs."



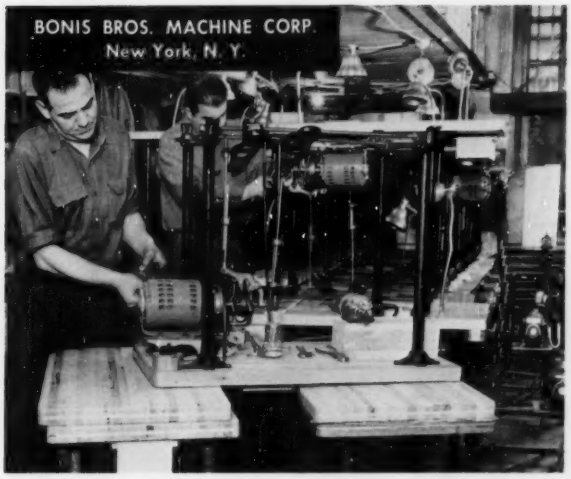
SIGNIFICANT COST SAVINGS

"The all-angle mounting of G-E fhp motors makes them especially suitable for use in our vegetable peeler. The sleeve-bearing design cuts our material costs, and small size aided product design."

QUIET OPERATION

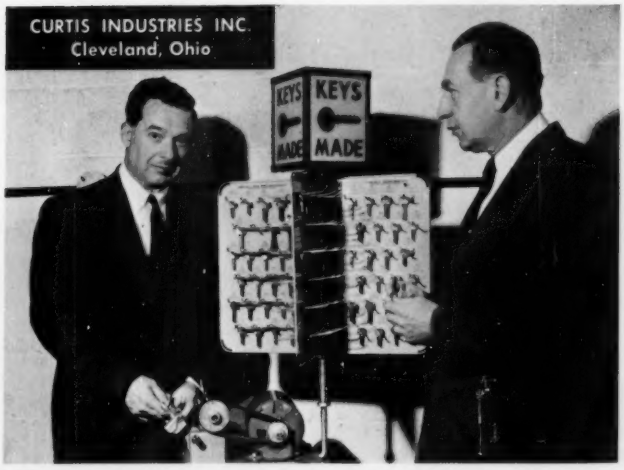
"Quiet motor operation is an important factor in oil and gas burners, and the silent operation of G-E fhp motors has become one of our big selling features. The G-E name helps sell our burners."

n produce results like these for you!



APPLICATION HELP

"Throughout the years, G-E engineers have been of immeasurable help in working out application problems on industrial sewing machines. We use G-E motors because they are superior to others."



MINIMUM SPACE REQUIREMENTS

"Our key machine is designed for retail merchants, and minimum counter space is important. It's also essential the unit be quiet operating. G-E fhp motors meet both of these requirements."

Here's Why G-E Fhp Motors Will Improve Your Product, Cut Your Costs

SMALLER SIZE of G-E fhp motors means a smaller, more compact product. The "years ahead" G-E motor is 40% smaller and 50% lighter in weight than old-style motor designs.

MINIMUM MAINTENANCE makes your product easier for customers to use. A 50% greater oil capacity and a highly efficient oil retention system provide double lubrication life, eliminate oiling completely on some applications.

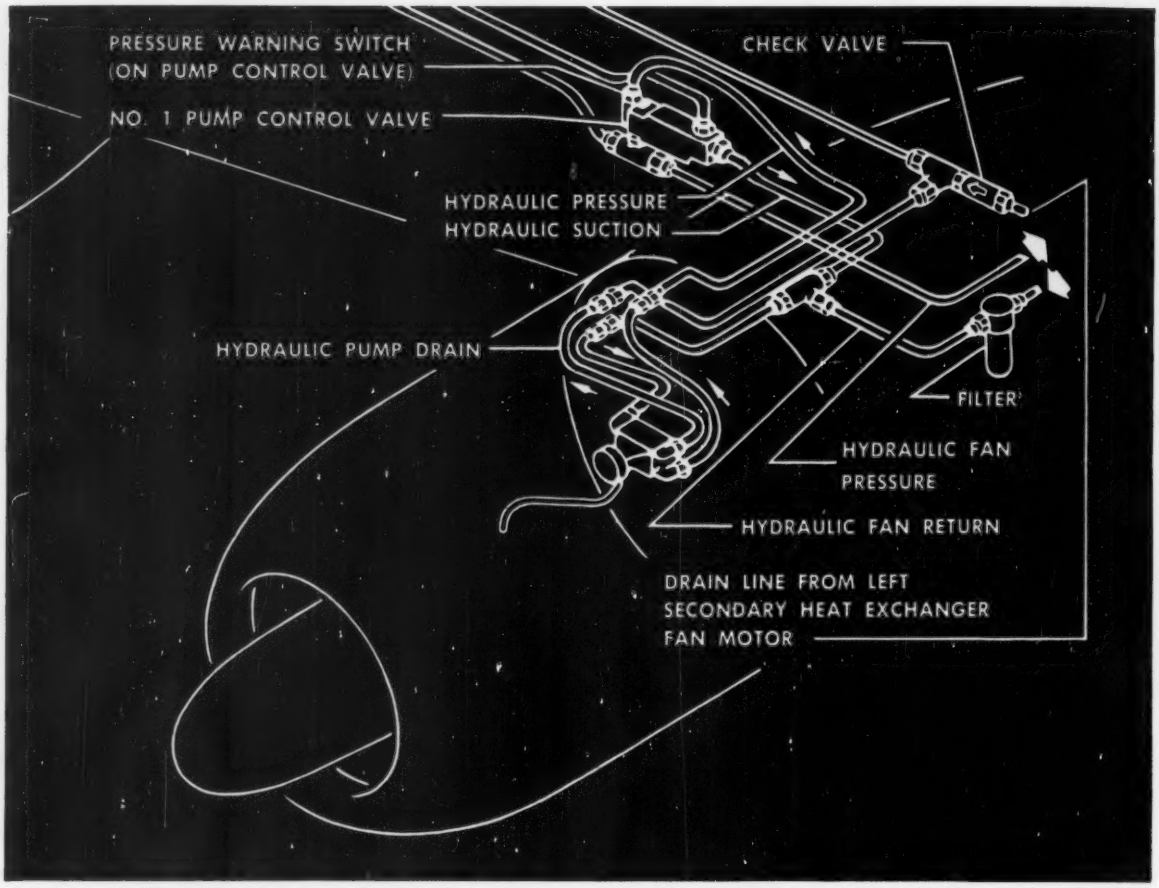
LONGER ELECTRICAL LIFE results from the use of Mylar* polyester film insulation. Mylar has a moisture resistance 35 times as great, and a dielectric strength 8 times as great as ordinary paper insulation.

COMPLETE MOUNTING VERSATILITY provides easy solutions to design problems. You can mount a G-E fhp motor in any position, and eliminate the need for costly "specials." Moreover, on both *solid* and *resilient* base motors, you can rotate the motor within its cradle or remove the cradle entirely to meet your exact requirements.

WANT MORE INFORMATION? Your nearby G-E Apparatus Sales Office will be glad to show you how you can improve *your* product with General Electric "years ahead" motors. They also can arrange for quick delivery of the motors you need. Write for Bulletin GEA-6424 to Section 702-49, General Electric Company, Schenectady 5, N. Y.

**Du Pont Registered Trade-mark*

GENERAL ELECTRIC



Where you can't afford a failure...
Plan a Purolator filter as part of your system

Most hydraulic systems break down immediately unless they are protected by adequate filtration. And it takes more than correct filter placement to assure adequate filtration — it takes the best filter you can get as well. That's why it pays to use Purolator Micronic® filters. They give you the fullest protection. The reason? Micronic elements — which provide controlled porosity and maximum filtration effectiveness with removal of particles as small as .000039 inch. And because they're made of plastic-impregnated cellulose, Purolator's Micronic elements are not affected by high temperature or water.

To find out more about proper placing of filters in hydraulic systems, write for our new 32 page "Filtration Manual for Product Designers"—and please enclose 25¢ to cover postage and handling. Address Dept. P4-38.

Filtration For Every Known Fluid

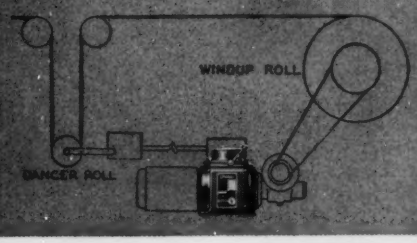
PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada

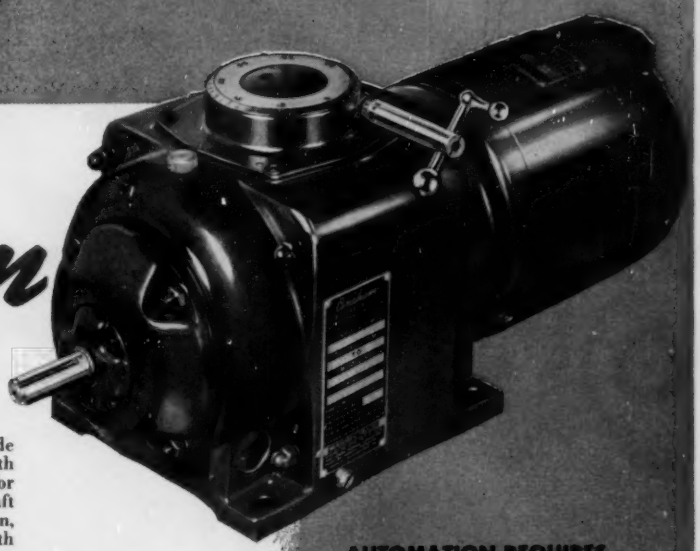
Circle 432 on page 19

FOR TRULY AUTOMATED CONTROL



NO AUTOMATION PROCESS CAN BE BETTER THAN THE VARIABLE SPEED DRIVE IT USES . . .

INSIST ON THE Graham variable speed drive



SIZES FROM FRACTIONAL TO 3 H. P.

There are four sizes of Graham — each in a wide variety of styles. All drives may be had either with built-in motor or with input shaft extension for coupling or belting to separate motor or to a shaft of the machine. Controls are either single turn, micrometer, lever or remote electrical control with speed indication at the remote point. Built-in motors may be had of nearly any desired mechanical and electrical type, open, totally enclosed, explosion-proof, motor with built-in brake included.

6 OUTSTANDING FEATURES

1. Ultimate in simplicity and compactness.
2. Unlimited speed range — from any desired maximum down to zero — including reverse if wanted without stopping the motor.
3. Unmatched for accuracy of speed setting and resetting and speed holding.
4. No perishable parts.
5. Twenty year performance record.
6. Low cost.

COMPLETE LINE OF BUILT-IN GEAR BOXES

The Graham gives every speed from any desired maximum down to zero (including reverse if wanted, without stopping the motor). The Graham should be so selected that the desired maximum speed of the driven shaft is had when the Graham is running at approximately its top speed. When this requires reduction or step-up gearing, this may be had without the cost and complication of a separate gearbox since the Graham is available with built-in single reduction or step-up spur gearing, single reduction worm gearing with output shaft horizontal or vertical, and double reduction helical gearing. Only four mounting bolts are required for the entire assembly—transmission, built-in motor and built-in gearbox—the ultimate in compactness.

AUTOMATION REQUIRES PERFECT TIMING

Where speeds must be held precisely . . . for long periods without measurable change; where hairline accuracy of resetting is essential; where absolute synchronism must be maintained between various machines performing a cycle of operations — Graham accuracy has been proved superior to all other variable speed drives.

The Graham maintains a guaranteed accuracy of .025% in length on a well-known tube-cutting machine; it gives .2% speed holding on an accelerator; it gives ¼% accuracy of dial setting on coil winding, with results as close as obtained on an adjoining machine using a selective gearbox; on an application involving repeated cycles of operation at varying speeds, the Graham drops or adds 1 cycle out of 3780 — an authenticated accuracy of .027% speed holding.

Mail This Coupon NOW . . .

GET Graham most reliable variable speed drive made

Because engineered and rated for continuous round the clock service

GRAHAM TRANSMISSIONS, INC.

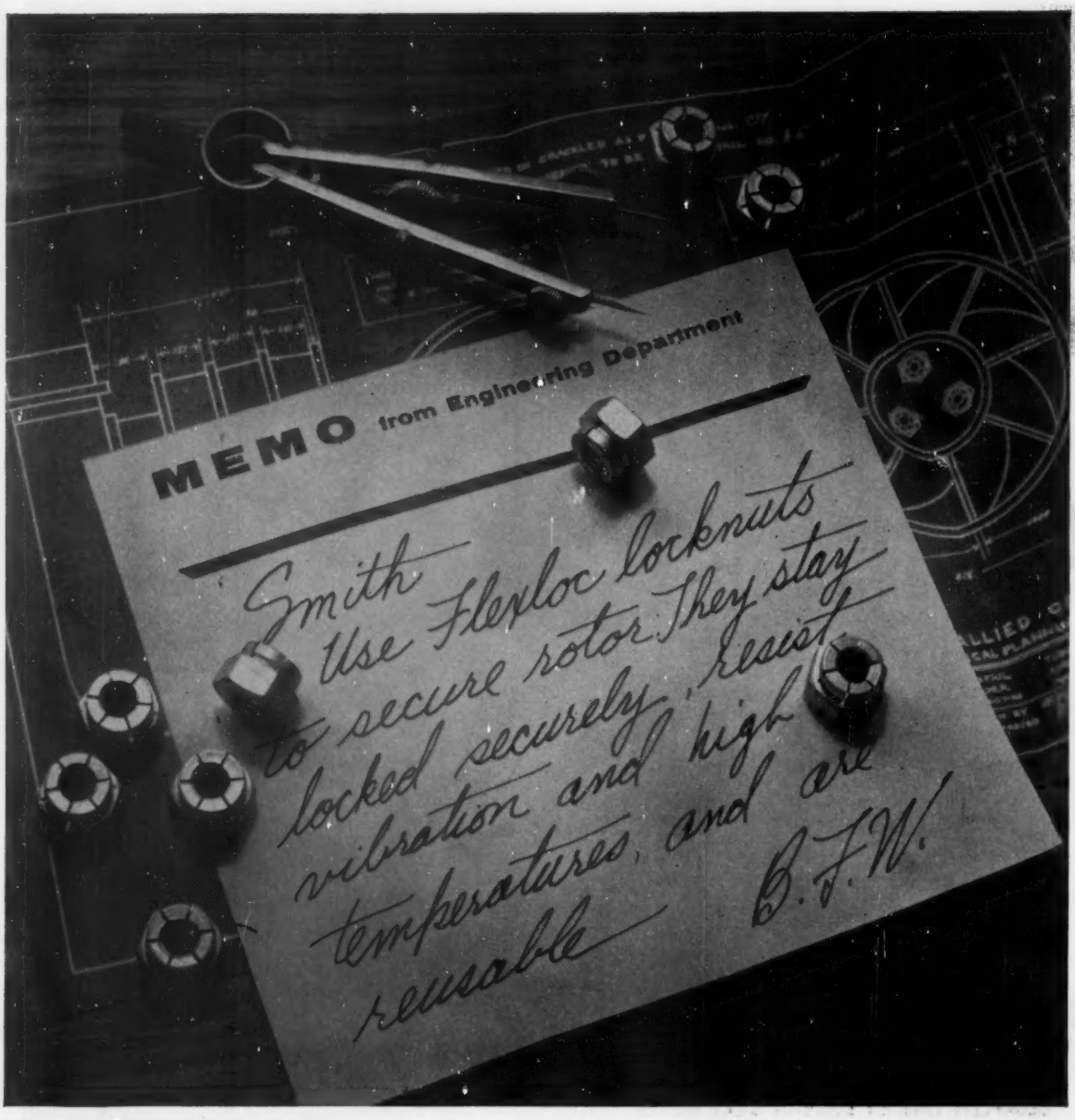
Gentlemen: Please send your latest catalog on Graham Variable Speed Drives.

Company.....

Name..... Title.....

Address.....

City..... Zone..... State.....



Vibration won't loosen FLEXLOC self-locking nuts

Where products must be reliable . . . must stand up under vibration, temperature extremes and hard use . . . designers specify rugged, reliable, precision-built FLEXLOC self-locking nuts.

HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting locking action. And they are reusable: repeated removal and replacement, frequent adjustments, even rough screw threads will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes, types and materials to meet the most critical locknut requirements. Your local industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

STANDARD PRESSED STEEL CO.

FLEXLOC® LOCKNUT DIVISION

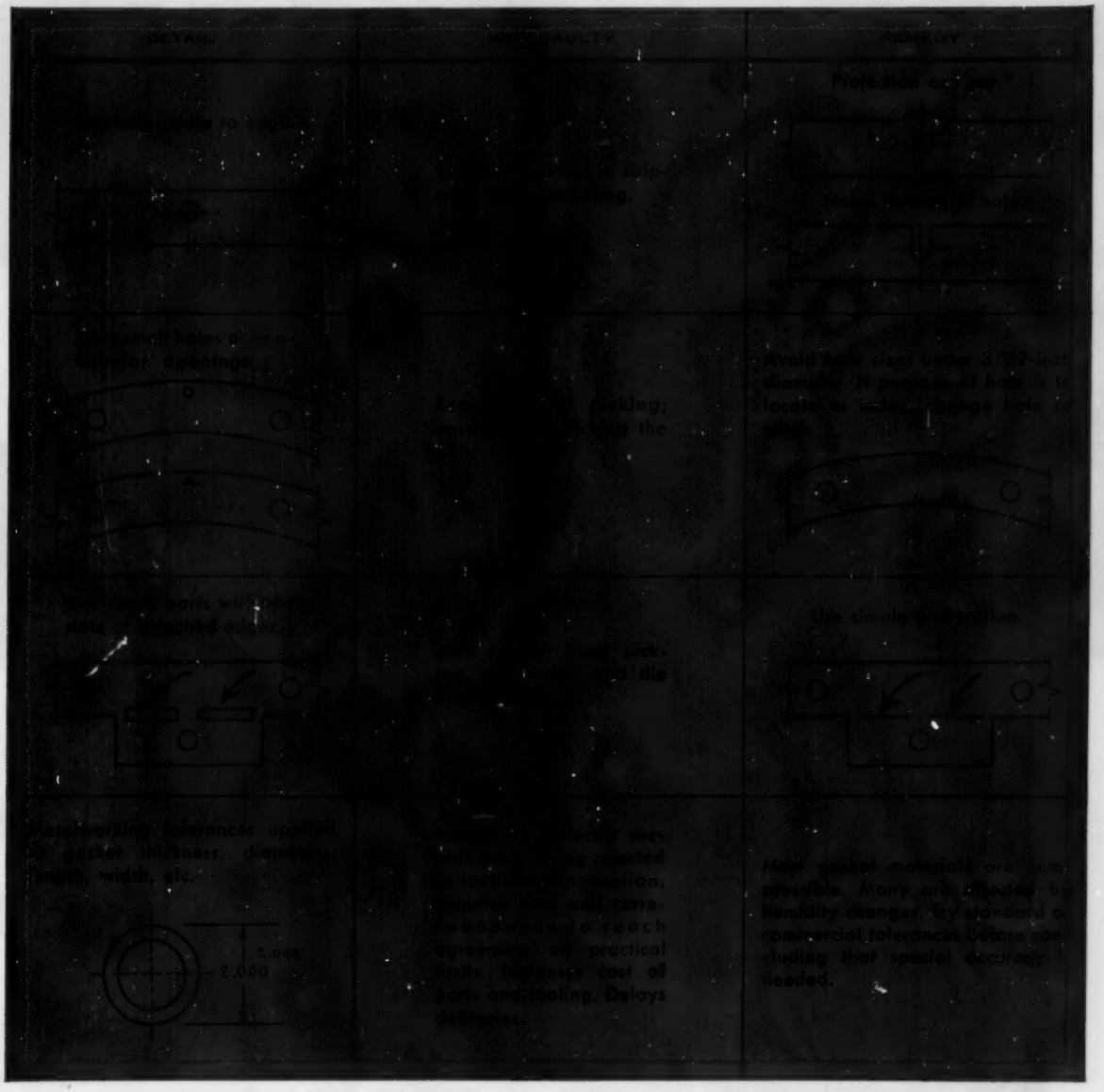
SPS

JENKINTOWN PENNSYLVANIA

Circle 434 on page 19

(Advertisement)

How to remedy four common errors in gasket design



As the examples above show, simple changes in gasket design or specification can result in savings in gasket cost and handling time.

Changes in joint design, too, can be helpful. Stiffening a flange, for example, will prevent flange bending —which has been found to cause about 90% of all joint leaks. Decreasing the gasket area and putting bolt holes closer together are other ways to cure this trouble. For more information on gasket selection and use, please write for the booklet shown at the right or call your Armstrong representative for assistance.

SEND FOR 1957 EDITION OF "ARMSTRONG GASKET MATERIALS"

This 16-page booklet discusses the choice of proper gasket materials and describes Armstrong cork, cork-and-rubber, synthetic rubber, and fiber sheet materials. Included are government and SAE-ASTM specifications. Look for this booklet in Sweet's product design file. Or for a personal copy, write Armstrong Cork Company, Industrial Division, 7103 Dean Street, Lancaster, Pa.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

Circle 435 on page 19

HOUGHTON . . .
Headquarters
for Hydraulics

ONE SOURCE for
to get the full potential

Choose hydraulic packings and fluids that work together —

Select them from *one proven source;* then you know they will be compatible; no divided responsibility. And they will give new life to the systems you design.

Packings should do more for you than just seal pressure. In fact, unless the packings you choose are as modern and well-engineered as the system itself, you're going to be short-changed on wear and performance.

Fluids, too, ought to do more than just transmit energy. Today's fluids should be able to satisfy any demands you make on them, ranging from fire-safety to their chemical and physical ability to hold up over long periods.

These Houghton packings and fluids illustrate the kind of "Extras" you need to give you *full* performance from every system you design:

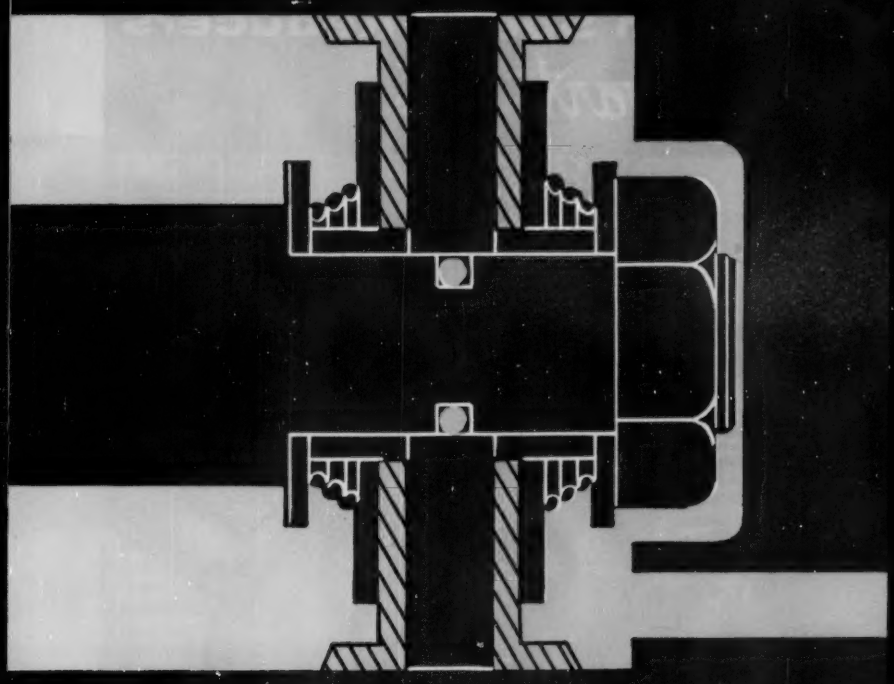
1243-3 Rubber-Impregnated Leather Cups. Resilient as rubber, but with leather's tough wear-power and anti-extrusion qualities. These packings have opened new fields for designers.

VIX-SYN Fabricated Synthetic Rubber Packings. These new packings are setting records for wear. In tests, cup packings have withstood as many as 28,000 wearing cycles at 4,000 psi without signs of failure.

VIX-SYN Homogeneous Synthetic Rubber . . . "U"-cups, "V"s and "O" rings . . . you'll find the same kind of advanced thinking reflected in the many special compounds available for varying service conditions and fluids.

Houghto-Safe 620. A non-petroleum, aqueous base hydraulic fluid which provides maximum fire resistance. In addition to complete fire safety, it helps packings give superior service because it is chemically inert to all standard packing materials. Its

Circle 436 on page 19



Spring Loaded
Cup Packings . . .
A HOUGHTON "First"

Packings and Fluids
of your design . . .

lubricity and film strength prolong pump and equipment life. Use it in over 80 percent of all hydraulic applications.

Houghto-Safe 1020. Where systems demand higher lubricating qualities along with fire-resistance, this new Houghton fortified phosphate ester type fluid is your best bet.

Hydro-Drive. In systems where petroleum fluids are safe, Hydro-Drive offers all the advantages of pure, high-quality oil plus chemically-increased film strength, lengthened service life, and fortified gum-dissolving, rust-preventing power.

Hydrolubric. As an additive for water-operated hydraulic systems, Hydrolubric very nearly makes oil out of water. It prevents rust, keeps evaporation to a minimum, and delivers positive, reliable lubrication to all working parts.

You get another assist from Houghton in packing engineering. Square shoulder cups and the wear-saving spring mount for cup packings are Houghton developments. Standard stack heights for "V" Packings is another innovation that lets you use any one of three kinds of packings in the same gland.

Write — or make sure to ask the Houghton Man when he calls at your plant — for full information on all the new Houghton developments for Hydraulic and Pneumatic equipment.

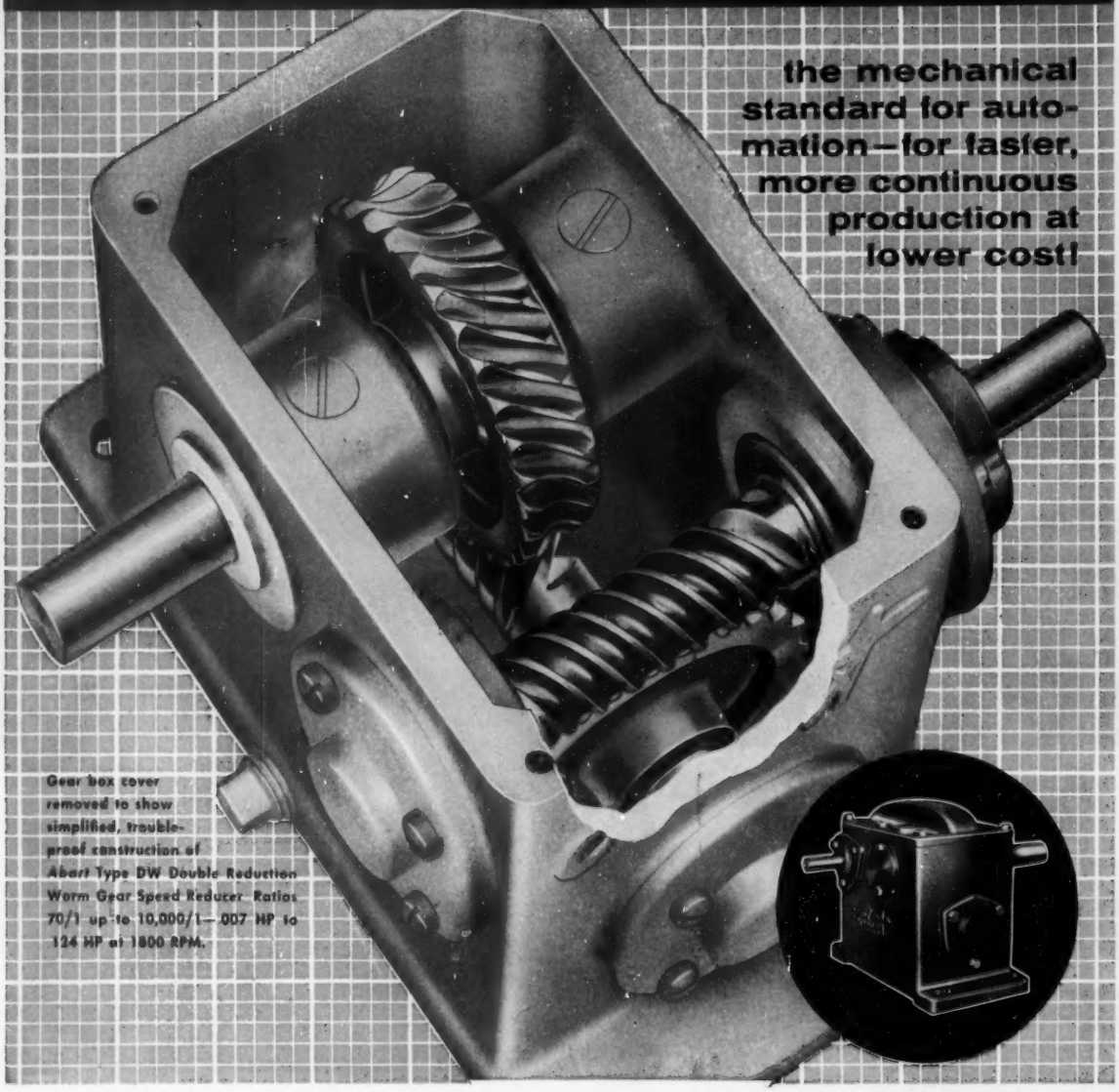
. . . products of

E F HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

Before you decide on Speed Reducers see the *Abart* line



the mechanical standard for automation—for faster, more continuous production at lower cost!

Gear box cover removed to show simplified, trouble-proof construction of *Abart* Type DW Double Reduction Worm Gear Speed Reducer. Ratios 70/1 up to 10,000/1—.007 HP to 124 HP at 1800 RPM.

cost less to operate... cost less to maintain!

Power packaged—engineered in over 75 sizes and types—adapted to all your Speed Reducer needs within these ranges:

SPUR GEAR REDUCERS:
Ratios 2/1 up to 400/1—up to 168 HP

SINGLE REDUCTION WORM GEAR REDUCERS:
Ratios 4-5/6 to 1 up to 100/1—1/2 HP to 98 HP

COMBINATION WORM and SPUR UNITS:
Ratios 116/1 up to 2000/1—.05 HP to 13 HP

FRACTIONAL HP TYPES:
Ratios 5-4/5 to 1 up to 100/1—1/50 HP to 2 HP

DOUBLE REDUCTION WORM UNITS:
Ratios 70/1 up to 10,000/1—.005 HP to 1 HP

Pocket size—new and revised Send today for this *Abart* Speed Reducer Engineering Data Book and Catalog *Write now.*

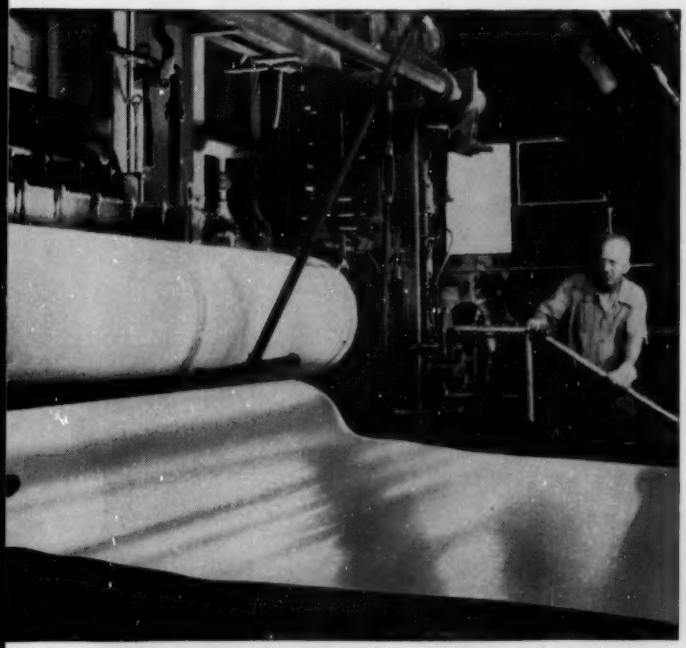
ABART GEAR and MACHINE CO.
4821 West 16th Street
Chicago 50, Illinois

Circle 437 on page 19

Circle 438 on page 19→

NOTHING *can equal Stainless Steel*

in its unique combination of properties



No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. If you're looking for a reliable source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS
PIPE • TUBES • WIRE • SPECIAL SECTIONS

USS

UNITED STATES STEEL

For Heat Resistance

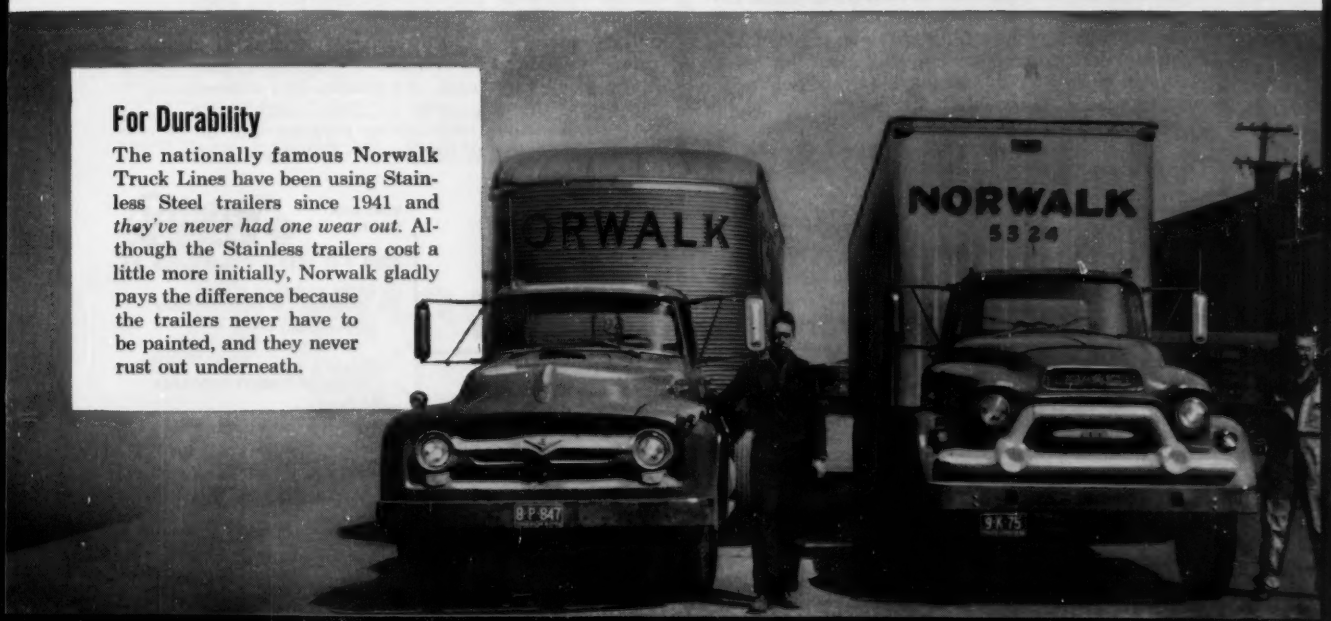
Pittsburgh Plate Glass Company wanted to increase the output of their glass tanks, so they needed better rolls to withstand the heat from the 2000° F. glass. They chose USS Stainless Steel Forgings for this critical location because Stainless resists cracking and oxidation, and retains its dimensions, even though in 24-hour-a-day service.

For Corrosion Resistance

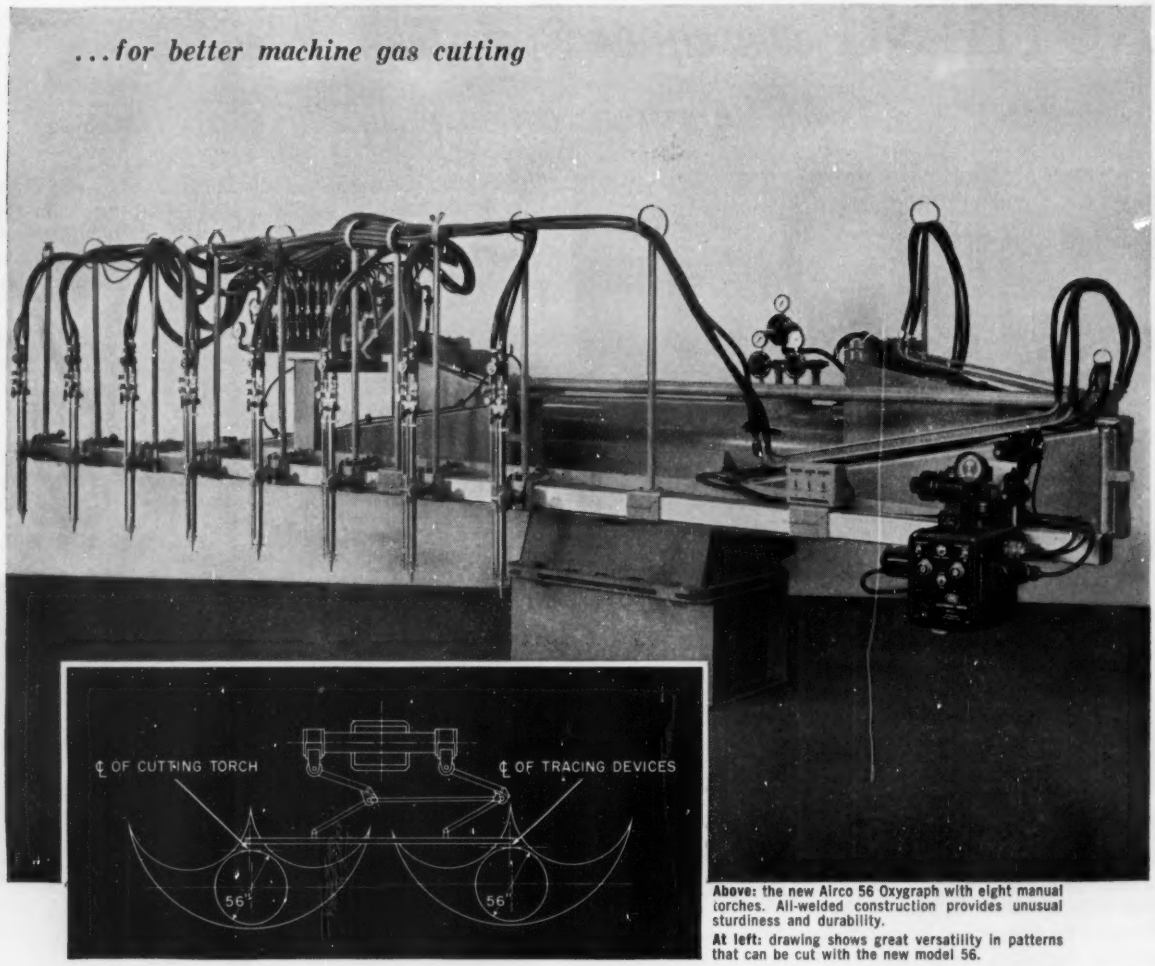
Calera Mining Co. operates the world's largest cobalt refinery, and the process involves leaching with a sulfuric acid solution. The Stainless Steel agitators shown here hold up at temperatures as high as 200° F., despite the high acid concentrations.

For Durability

The nationally famous Norwalk Truck Lines have been using Stainless Steel trailers since 1941 and *they've never had one wear out.* Although the Stainless trailers cost a little more initially, Norwalk gladly pays the difference because the trailers never have to be painted, and they never rust out underneath.



...for better machine gas cutting



Above: the new Airco 56 Oxygraph with eight manual torches. All-welded construction provides unusual sturdiness and durability.

At left: drawing shows great versatility in patterns that can be cut with the new model 56.

NEW... Airco 56 Oxygraph

...for better machine gas cutting of larger work on production schedules

This newly developed Airco 56 Oxygraph meets the demand for a multi-torch oxy-acetylene shape cutting machine that will handle substantially large areas. It *cuts* a *full 56" circle*, and corresponding square and rectangular shapes. Rugged box girder design is used for the pantograph arms, holding vibration to a minimum. Tracer response is smooth and friction-free as a result of large diameter ball bearings in the pantograph hinges and operating bar assembly.

This newest of Airco Oxygraphs will cut an unlimited variety of shapes from steel plates, slabs, billets and forgings. Flexibility of design allows amplifying scope of machine to meet increased shop demands. Tracers are available in four types: electronic, manual, magnetic and spindle. This widened capacity of the new model 56 marks another step forward in welding and cutting progress. For detailed information on the New 56 Oxygraph, write direct to Airco.

welding
AT THE FRONTIERS OF PROGRESS YOU'LL FIND...

AN AIR REDUCTION PRODUCT

VISIT OUR BOOTH 334 WELDING SHOW

APRIL 9-11, 1937 • PHILADELPHIA, PA.

AIRCO®

Offices and dealers in most principal cities

AIR REDUCTION SALES COMPANY

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150 East 42nd Street, New York 17, N. Y.

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In Cuba —
Cuban Air Products Corporation

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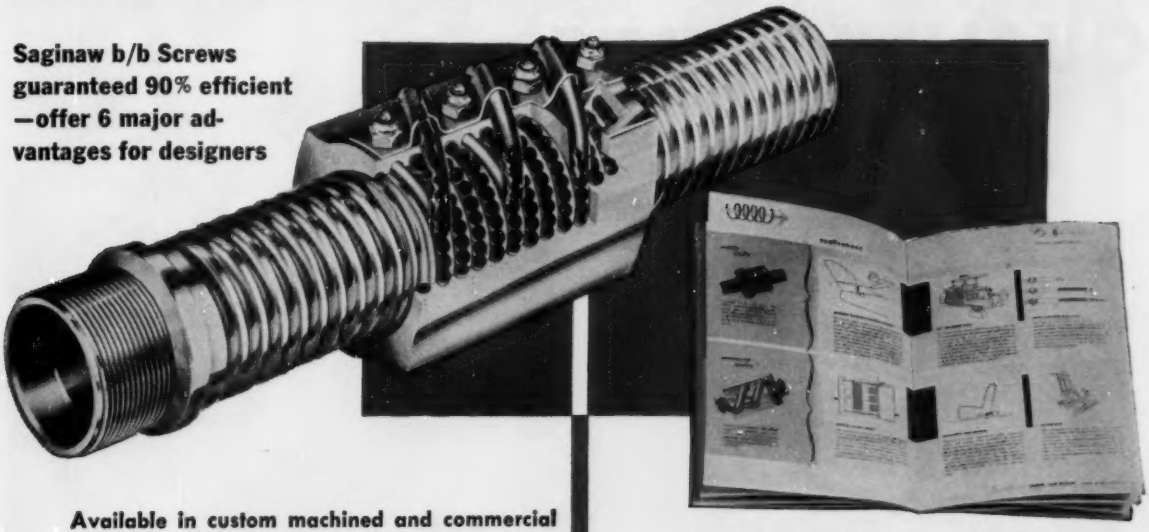
Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide, liquid-solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetates, alcohols, and other synthetic resins.

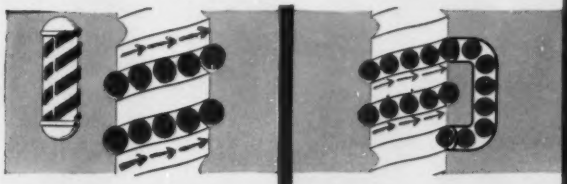
ACTUATION PROBLEM too tough for ordinary devices?

SAGINAW CAN HELP YOU SOLVE IT!

Saginaw b/b Screws guaranteed 90% efficient —offer 6 major advantages for designers



Available in custom machined and commercial rolled thread types—have been built from 1½ inches to 39½ feet long—⅜ to 10 inches diameter.



Nut *glides* on steel balls. Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.

At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

1 VITAL POWER SAVINGS. With guaranteed efficiency of 90%, Saginaw b/b Screws are up to 5 times as efficient as Acme screws, require only ⅕ as much torque. This permits much smaller motors with far less drain on the electrical system. Circuitry is greatly simplified.

2 SPACE/WEIGHT REDUCTION. Saginaw b/b Screws permit use of smaller motors and gear boxes; eliminate pumps, accumulators and piping required by hydraulics. In addition, Saginaw b/b Screws themselves are smaller and lighter. Units have been engineered from 1½ in. to 39½ ft. in length.

3 PRECISE POSITIONING. Machine-ground Saginaw b/b Screws offer a great advantage over hydraulics or pneumatics because a component can be positioned at a predetermined point with precision. Tolerances on position are held within .0006 in./ft. of travel.

4 TEMPERATURE TOLERANCE. Normal operating range is from −75° to +275° F., but assemblies have been designed in selected materials which function efficiently as high as +900° F. These units are practical where hydraulic fluids have lost efficiency or reached their flash point.

5 LUBRICATION LATITUDE. Even if lubrication fails or cannot originally be provided because of extreme temperatures or other problems, Saginaw b/b Screws will still operate with remarkable efficiency. Saginaw units have been designed, built and qualified for operation without any lubrication.

6 FAIL-SAFE PERFORMANCE. Far less vulnerable than hydraulics. In addition, Saginaw offers three significant advantages over other makes: (1) Gothic arch grooves eliminate dirt sensitivity, increase ball life; (2) yoke deflectors and (3) multiple circuits provide added assurance against operating failure.

YOUR FREE COPY OF THIS NEW b/b SCREW AND SPLINE "PROBLEM SOLVER" SHOWS HOW

36 pages crammed with time-, work-, and money-saving facts: Principles • Types • Basic Operations • Coupling Methods • Efficiency • Advantages • Selection Factors • Design Data • Sample Problems

SAGINAW b/b SPLINE

● Averages 40 times lower coefficient of friction than ordinary sliding splines!

Utilizing the same basic *gliding ball* principle, Saginaw has developed the *Saginaw b/b Spline* which radically increases the efficiency of transmitting or restraining high torque loads.

It can be fitted with integral gears, clutch dogs, bearing and sprocket seats, etc. Units have been built from 3 inches to 10 feet long—⅜ to 6 inches in diameter.

SEND TODAY FOR THIS FREE 1957 ENGINEERING DATA BOOK...

or see our section in Sweet's Product Design File

Saginaw ball bearing Screws and Splines

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS

WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

Saginaw Steering Gear Division
General Motors Corporation
b/b Screw and Spline Operation
Dept. 7H, Saginaw, Michigan

Please send new engineering data book on Saginaw b/b Screws and Splines to:

NAME _____

COMPANY _____ TITLE _____

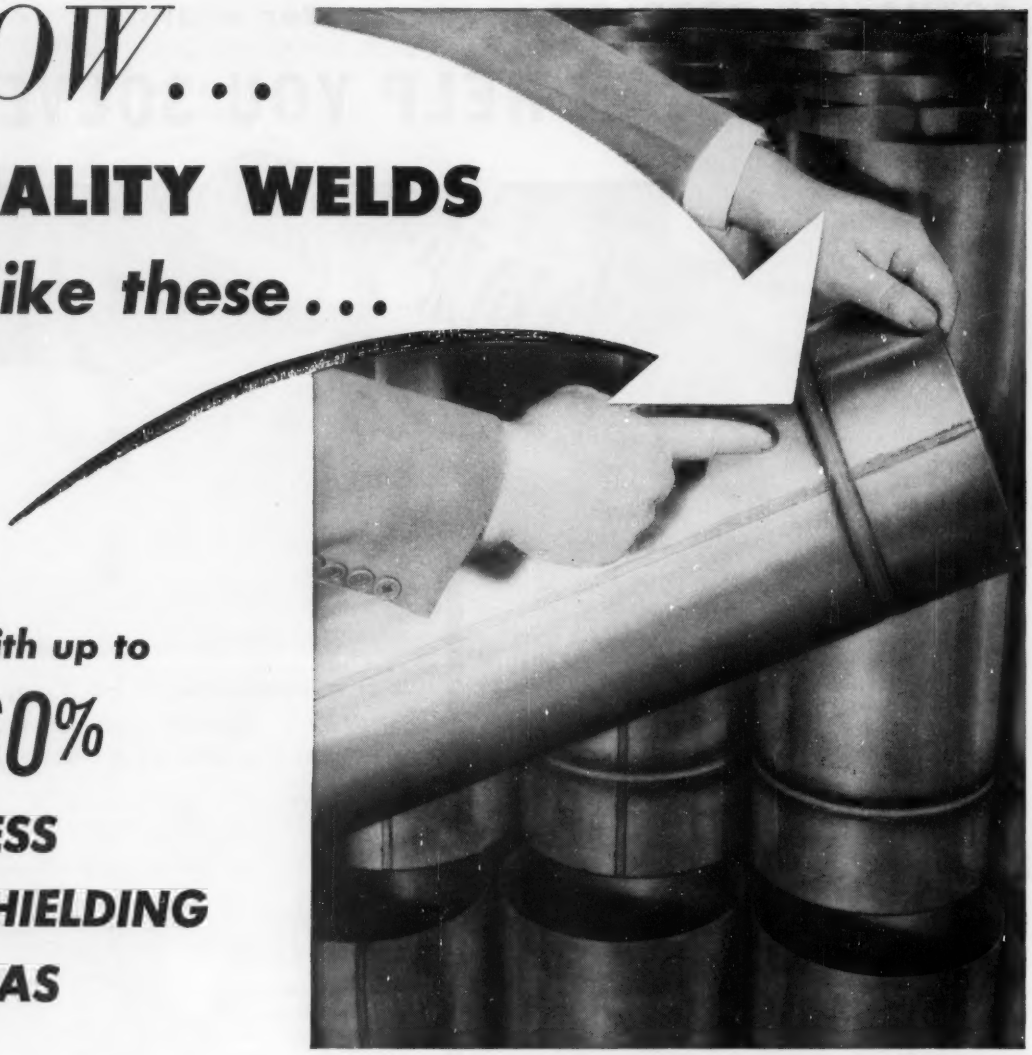
ADDRESS _____

CITY _____ ZONE _____ STATE _____

NOW...

QUALITY WELDS

like these...



with up to

60%

LESS SHIELDING GAS

H-15 argon-hydrogen mixture means new economy in fast, sound welding operations.

Using H-15, a LINDE mixture of argon and hydrogen shielding gases, savings as high as 60% of normal gas consumptions are being attained by manufacturers on a wide variety of metal products. This mixture is designed for extremely efficient mechanized welding of stainless steel, Monel, Inconel, and cupro-nickel.

COMBINES ADVANTAGES—H-15 mixture combines the high welding speed feature of Helium with the low consumption advantages of argon—result, the lowest cost, high-quality welding yet attained . . . And no extra equipment is needed for a change over to H-15.

Get the complete story of this highly efficient, economical mixture, contact your local LINDE representative. Start saving now—do it today.

Linde Air Products Company

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York 17, N. Y.

Offices in Other Principal Cities

In Canada: LINDE AIR PRODUCTS COMPANY

Division of Union Carbide Canada Limited, Toronto

The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.

Linde
Trade-Mark

Precision motorized spindle built by Pope Machinery Corporation

THE PEOPLE AT POPE SAY:

DON'T ✣ combine the bearing loads— DIVORCE ↕/↔ them!

Greater rigidity, accuracy, and capacity; lower friction and temperatures under varying loads and speeds; smoother, chatter-free operation that spells finer finishes at lower cost . . . these are the plus advantages offered by Pope precision spindles because they feature the single-direction bearing principle: radial bearings for the radial loads—thrust bearings for the thrust loads.

Aetna spindle thrust bearings, like the special, preloaded, double-acting type used by Pope Machinery Corporation, are built to super-rigid standards of concentricity, parallelism, size, finish and metallurgical structure. They are typical of the many design-engineering successes which have earned Aetna's reputation as a progressive and dependable bearing supplier to the machine tool industry for over forty years.

Perhaps you, too, can use Aetna's forward-thinking engineering teamwork to good advantage. It's teamwork you can swing into action simply by writing us or 'phoning the representative listed under the Aetna trade-mark in your classified 'phone book. Why not do it today?

Standard and Special Ball Thrust Bearings • Angular Contact Ball Bearings • Special Roller Bearings • Ball Retainers • Hardened and Ground Washers • Sleeves • Bushings • Miscellaneous Precision Parts

AETNA BALL AND ROLLER BEARING COMPANY
Division of Parkersburg-Aetna Corporation
4600 Schubert Avenue • Chicago 39, Illinois

Circle 442 on page 19

GARLOCK and Announce

THE COMPLETE INTEGRATION OF THEIR SALES FORCES

Now, the United States Gasket Company will be known as the United States Gasket Company, Plastics Division of The Garlock Packing Company.

In August 1955 Garlock acquired the United States Gasket Company. Subsequently, the production facilities of both companies were integrated. Now, it is clear that the customers of both companies will be better served through an integrated sales force.

Better Service for Customers

Both U.S.G. and Garlock customers will now enjoy the finest, most complete service available in the fields of fluorocarbons (Teflon* and Kel-F**), nylon and other plastics as well as mechanical packings and seals of all types. Specialists in specific materials and applications will always be available for consultation on your problems.

Saves You Time

This integration of sales forces will also simplify your purchasing problem . . . you can standardize on one reliable source of supply and have more time to devote to other important problems.

Unbiased Recommendations

With the addition of U.S.G. plastic products to the famous "Garlock 2,000" family of packings, gaskets, and seals, your local representative is able to supply the right seal for every conceivable need. Call him at the office nearest you.

30 Sales Offices

U.S.G. plastics specialists join the 125 Garlock salesmen at 30 sales offices and warehouses where large stocks of plastic products are stored. This means faster deliveries from local stocks, as well as expert plastics and sealing assistance as close as your telephone.

*DuPont Trademark
**M.W. Kellogg Trademark

Main Factory Buildings of The Garlock Packing Company, Palmyra, New York. Other factories in San Francisco and Canada.

One of the two Camden, N.J. plants of the United States Gasket Company, Plastics Division of The Garlock Packing Company

United States Gasket

UNITED STATES DISTRICT OFFICES AND WAREHOUSES

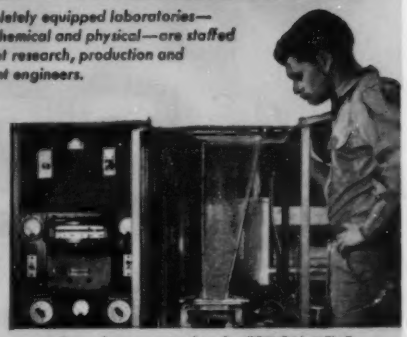
Baltimore 18, Md., *2828 Lock Raven Rd.*
Birmingham 1, Ala., *519 S. 19th St.*
Boston 10, Mass., *80 Broad St.*
Buffalo 2, N.Y., *38 Pearl St.*
Chicago 6, Ill., *600 W. Jackson Blvd.*
Cincinnati 16, Ohio, *8329 Vine St.*
Cleveland 13, Ohio, *1276 W. Third St.*
Denver 2, Colo., *1863 Wazee St.*
Detroit 11, Mich., *2781 E. Grand Blvd.*
Houston 3, Texas, *2105 McKinney Ave.*
Los Angeles 21, Calif., *2303 E. 8th St.*
New Orleans 25, La., *3525 Lowerline St.*
New York 6, N.Y., *114 Liberty St.*
Palmyra, N.Y., *Maple Ave.*
Philadelphia 2, Pa., *20 S. 15th St.*
Pittsburgh 22, Pa., *933 Penn Ave.*
Portland 9, Ore., *1036 N.W. 18th Ave.*
Salt Lake City 1, Utah, *322 Dooly Bldg.*
San Francisco 7, Calif., *750 — 18th St.*
St. Louis 8, Mo., *3635 Forest Park Blvd.*
Seattle 4, Wash., *814 Lane St.*
Spokane 4, Wash., *W. 610 Second Ave.*
Tulsa 20, Okla., *816 E. 6th St.*

CANADIAN OFFICES AND WAREHOUSES

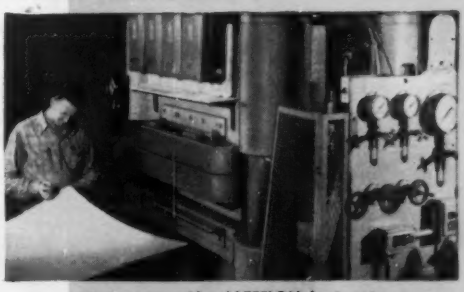
Edmonton, Alb., *8407 — 103rd St.*
Hamilton, Ont., *200 Queen St.*
Montreal 9, Que., *5214 De La Savane St.*
Toronto 2, Ont., *750 Bay St.*
Vancouver 5, B.C., *1925 W. Georgia St.*
Winnipeg 3, Man., *1436 Erin St.*

SPECIALIZED PLASTICS PRODUCTS FACILITIES AT U.S.G.

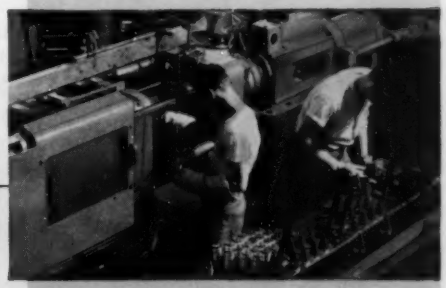
Three completely equipped laboratories—electrical, chemical and physical—are staffed by top-flight research, production and development engineers.



One of many extruders for TEFLON, KEL-F and nylon rods, tubes and special shapes.



Giant presses cold mold TEFLON sheets up to 48" x 48" in size, ready for sintering.



High product, low-cost injection molding of thermoplastic parts to manufacturers specifications.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints, Fluorocarbon Products

Circle 443 on page 19

GET GREATER GRINDER PRODUCTION BETTER SURFACE FINISHES LOWER PRODUCTION COST

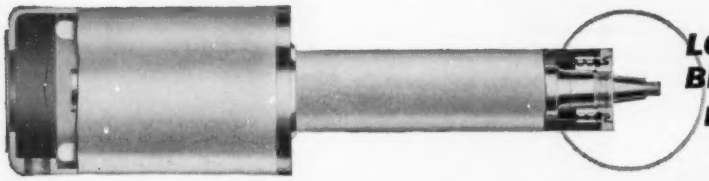
From all your Surface Grinders, new or old

Specify POPE HEAVY DUTY, MOTORIZED SPINDLES

POPE 1, 2 and 3 HP, 1800 or 3600 RPM Surface Grinder Spindles:

- **assure continuous production of accurate parts.**
- **revolve accurately under the heaviest loads.**
- **permanently lubricated (Pope System) for the life of the bearings.**
- **have the rigidity to support diamond wheels and to produce *more good work.***
- **have the extra rigidity for crush dressing and form grinding.**

WRITE FOR PRICE AND DELIVERY.



LOOK AT THE BEARINGS! permanently preloaded

These super-precision, double row cylindrical roller bearings have the capacity to assure smooth, chatter-free operation over a long life — give the Spindle the ability to rough off surplus metal fast but maintain its inbuilt precision for producing fine finishes.

Separate super-precision ball thrust bearings eliminate endwise movement of the shaft in either direction.

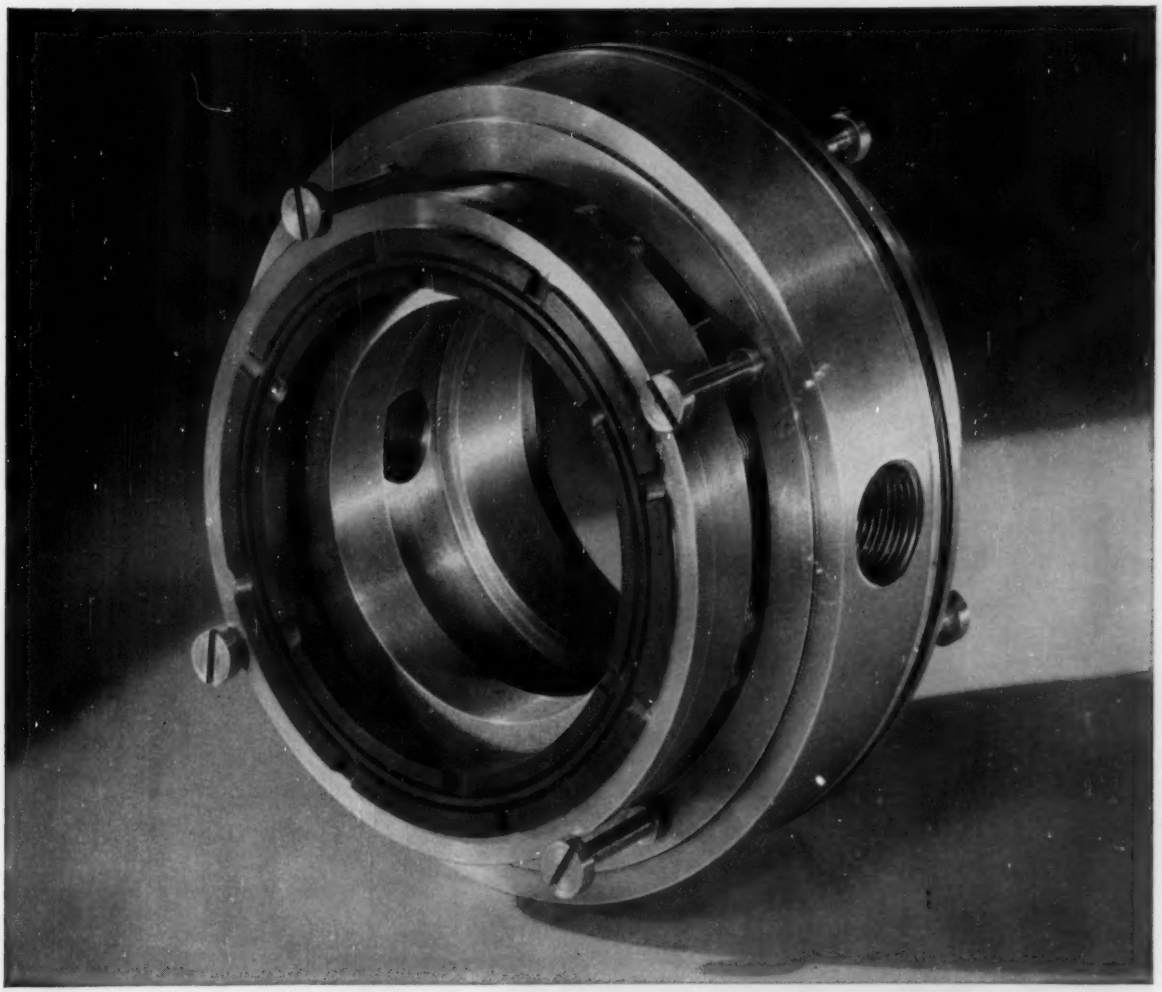
No. 117

POPE® **ENGINEERS AND BUILDS STANDARD AND SPECIAL PRECISION ANTI-FRICTION BEARING SPINDLES FOR EVERY PURPOSE**

POPE MACHINERY CORPORATION • 261 RIVER STREET • HAVERHILL, MASS.

Established 1920

Circle 444 on page 19



Koppers Face Type Seal Provides Up to 20,000 Hours of Service!

Up to 30,000 Hours in Laboratory Tests Using Clean Gas!

Koppers engineering has created an unmatched sealing surface that gives Koppers Face Type Seals a much longer-than-ordinary service life.

The exclusive design of the sealing surface keeps pressure distribution and hydraulic balance unchanged during operation . . . permits a light face loading which lowers interface temperatures. Hydraulic balance allows sealing of gases and liquids through a wide range of rubbing speeds. Rugged construction adds to Koppers long service life. Rotating collars can be of hardenable stainless steels, cutlery and die steels, Stellites, or of a hard chromium or carbide face. Ring is of carefully selected grades of carbon.

If you have a sealing or piston ring problem, Koppers entire research, production and engineering facilities are at your disposal. For more details, write to the KOPPERS COMPANY, INC., 2303 Hamburg St., Baltimore 3, Maryland.

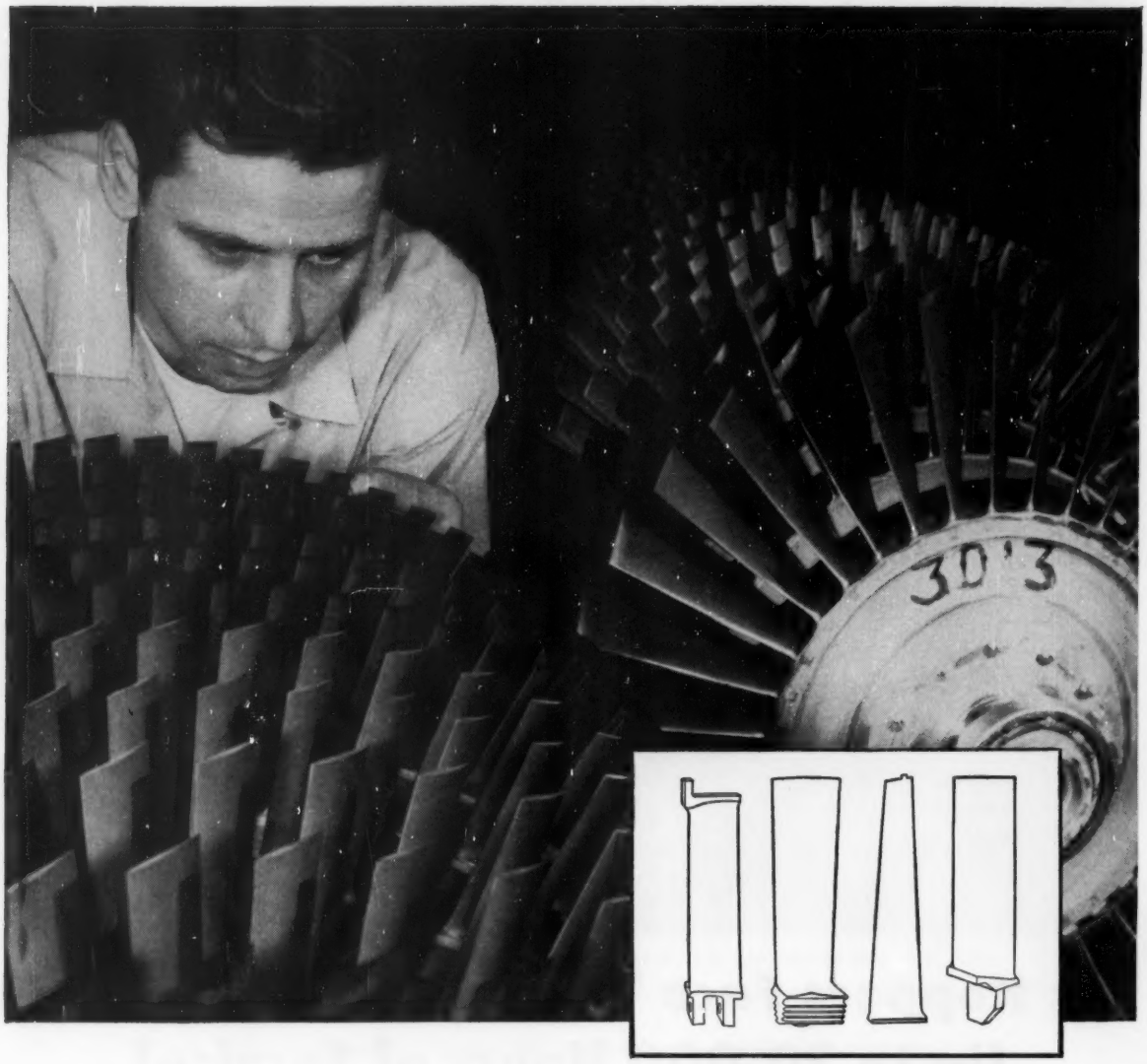
Koppers Company, Inc.
Metal Products Division
Piston Ring and Seal Dept.

***Engineered* Products**
Sold with *Service*

KOPPERS®

MECHANICAL SHAFT SEALS

Circle 445 on page 19



Curtiss-Wright **PROTOTYPE SERVICE** speeds you from blueprint to working model

Here's the fast, efficient and economical way to get working models from your turbine or compressor blade designs . . . whether you want a single prototype or test production quantities. Curtiss-Wright's Metals Processing Division scales down its complete facilities in a modern, geared-to-speed prototype shop . . . brings under one roof all the production steps from primary metal to finished product in any high integrity alloy.

Working model production brought to a fine point of precision control means more accurate development now . . . smoother flowing production later. Coordinated facilities for casting, forging, grade rolling, machining and extrusion are ready to serve you on short notice . . . solve your problems in a hurry. Contact Curtiss-Wright when your next set of designs leaves the drafting board. Qualified engineering consultation available at all branch offices.

For complete details, write to: 71 Grider Street

METALS PROCESSING DIVISION
CURTISS-WRIGHT
CORPORATION • BUFFALO, NEW YORK

METALS PROCESSING DIVISION BRANCH OFFICES: • • • NEW YORK • HOUSTON • LOS ANGELES

Circle 446 on page 19

BUTTERFLY VALVE BODY

This guided missile component, type 304, A296-49T CF-8, had previously been fabricated. ESCO multiple-unit centrifugal casting technique (SPUNCAST ®) was used, casting six valve bodies, each weighing 180 pounds, at one time resulting in an overall saving in time and material amounting to 30% of former costs.

Before you say, "It can't be cast,"

call an ESCO Engineer

ESCO alloy steel castings can make your designing *easier*. You get the part you want, in the alloy you need and in the shape that saves you the most fabricating, machining and finishing time ... **PLUS**

METALLURGICAL ENGINEERING AND RESEARCH

ESCO maintains one of the largest and best equipped metallurgical staffs of any alloy steel foundry ... **PLUS**

PRODUCT ENGINEERING AND DESIGN

An integrated service at all levels; in the field, at the drawing board and in the foundry ... **PLUS**

FOUNDRY FACILITIES AND CASTING EXPERIENCE

A casting service that covers the complete range of alloy steel casting methods for all applications ... **PLUS**

LABORATORY INSPECTION AND TESTING

ESCO laboratory technicians are qualified and equipped to perform all types of inspections and testing to the most rigid specifications.

Call an ESCO Engineer — let him show you how ESCO Alloy Steel Castings can help make your designing easier.

ESCO

ELECTRIC STEEL FOUNDRY COMPANY

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MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.

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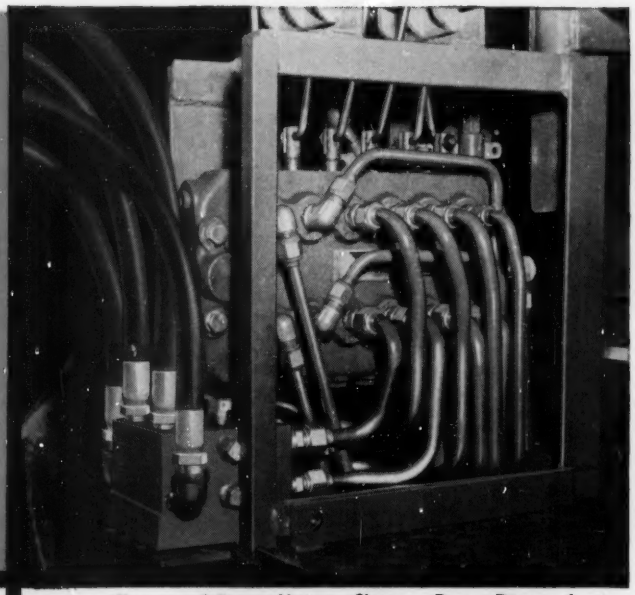
IN CANADA ESCO LIMITED

Write today for your FREE copy of this informative 100-page reference book — "ESCO Alloy and Stainless Steels for the Process and Manufacturing Industries".

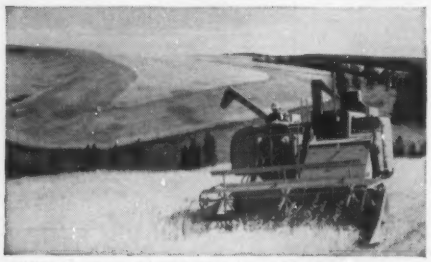
Circle 447 on page 19

FULL PAYLOAD POWER

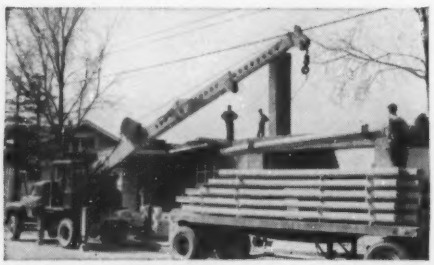


Close-up of Power Unit on Sherman Power Digger showing direct power delivery *from lever to load.* Pilot model equipped with Eastman Hydraulic Hose and Tube Assemblies.

International Harvester Model 75 Payscraper. First application of hydraulic steering on earth movers. USER OF EASTMAN EQUIPMENT.



Allis-Chalmers Model 100 ALL CROP Harvester. Steering brakes and header height hydraulically operated. USER OF EASTMAN EQUIPMENT.



Bucyrus-Erie Model H-5 Hydrocrane. Hydraulically controlled boom, out riggers and bucket. USER OF EASTMAN EQUIPMENT.

FOR FULL PAYLOAD POWER FROM LEVER TO LOAD specify

Eastman

HYDRAULIC HOSE ASSEMBLIES

For full payload power—*from lever to load*—consistent with long-lasting service, safety and sound construction—always specify Eastman Hydraulic Hose Assemblies.

Eastman, *first in the field* of Hydraulic Hose Assemblies, developed many original engineering advantages in design, construction and assembly—time tested by *unequalled* years of experience.

Since Eastman pioneered in the very first applications of mobile hydraulic power . . . you will find Eastman Hydraulic Hose Assemblies used by many original equipment manufacturers who were pioneers in their respective fields also.

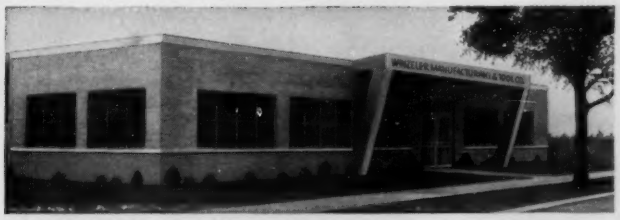
Let *their endorsement be your assurance* of the satisfactory hydraulic performance of your products, too—plus the prestige and competitive sales advantage that comes with quality Eastman Hydraulic Hose and Tube Assemblies—*the Standard of the Industry!*

It pays to write Eastman ***FIRST...*** *because Eastman was first in the field of Hydraulic Hose Assemblies*

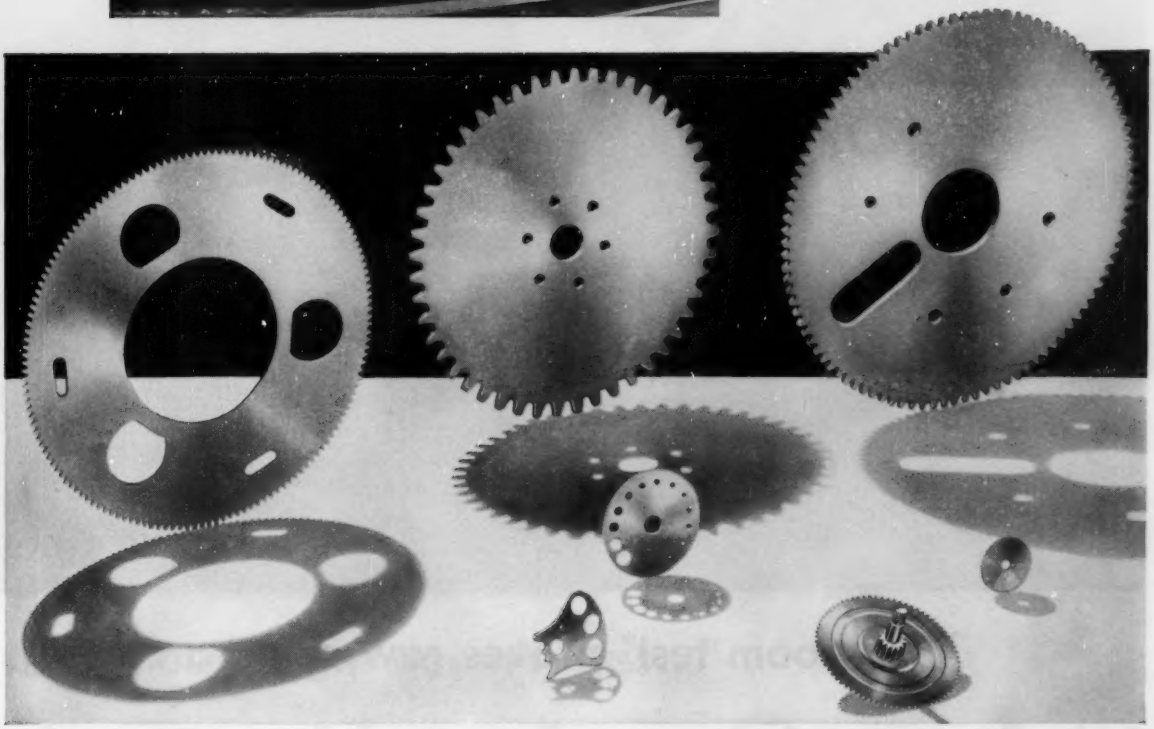
Eastman *first in the field*

MANUFACTURING COMPANY, Dept. MD-3, MANITOWOC, WIS.

The Outstanding Success of Winzeler STAMPED Gearing Results from Vastly Improved Methods of Tooling, Stamping and Inspection



Winzeler accuracy and efficiency is now greater than ever in this brand new, specially designed, one-floor plant. Here, highly developed men, methods and machines keep pace with the rapidly increasing demand for the better Stamped Gearing we make.



WINZELER is now better equipped than ever to *Stamp* Gearing in production runs. Greatly enlarged, modernized plant, methods and equipment produce Gearing by the thousands or *millions* with a degree of speed and uniform accuracy generally considered impossible! Skilled WINZELER engineers can lend you valuable aid in determining the ONE best and most economical application for your specific needs.

WINZELER now *stamps* better Gearing from *8 to 120* dp . . from .006 to 3/16" thickness and up to 7 inch diameter. Single stampings are often laminated and indexed to produce wider faces at savings up to 60%! Now, BAKELITE Gearing is successfully stamped and shaved, with special tooling, from material up to 1/8" thick. Teeth are sharp, clean-cut, uniformly accurate. Join the fast-growing group of critical customers who improve quality, performance and profits by using WINZELER *Stamped* Gearing exclusively. Write us now about *your* needs.

WINZELER *Stamped Gears*

MAIL THE COUPON FOR FREE STAMPED GEAR FOLDER

WINZELER MANUFACTURING & TOOL CO.,
7355 W. WILSON AVENUE, CHICAGO 31, ILLINOIS

Gentlemen:

Please mail to me, at once, a copy of the free WINZELER Stamped Gear folder.

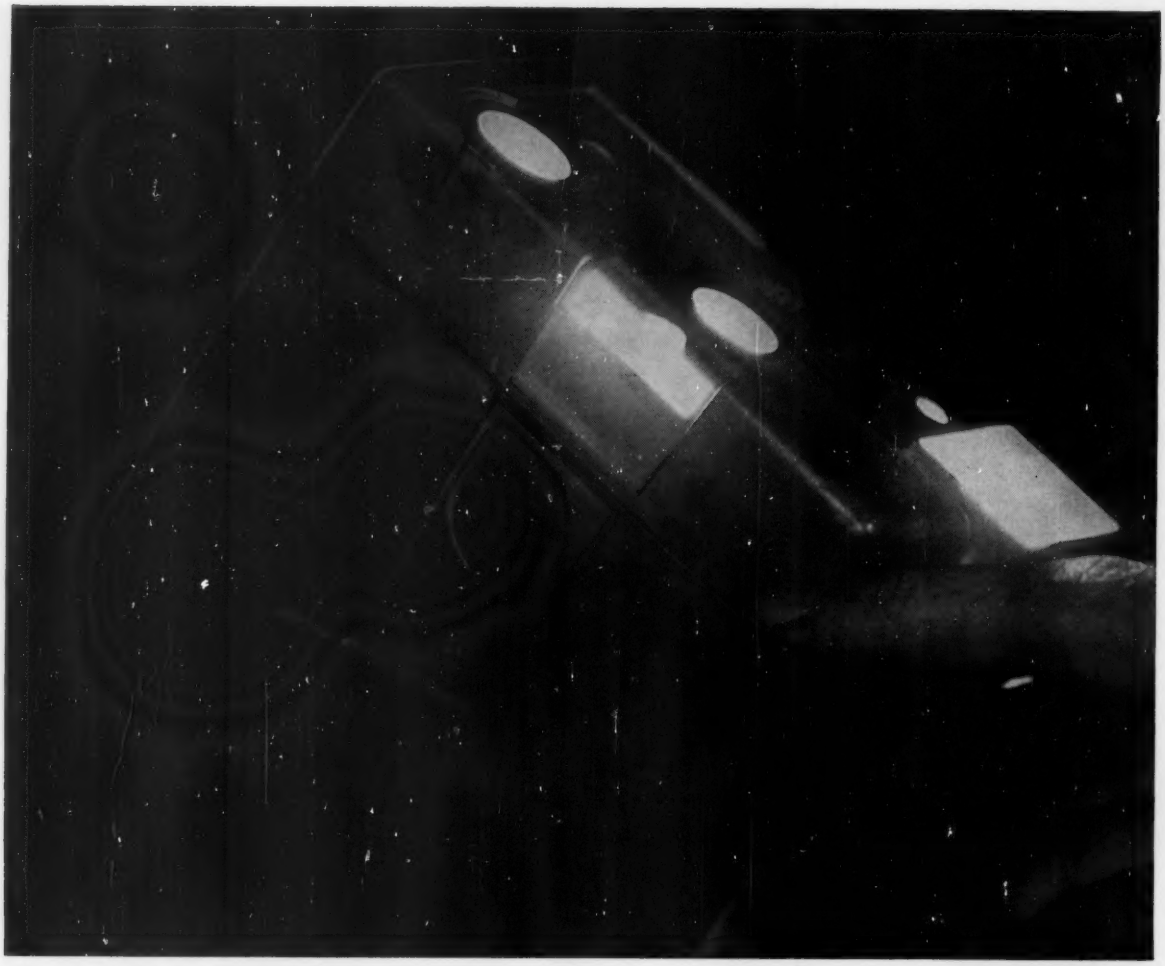
NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

Circle 449 on page 19



"Darkroom test* proves raw camera castings

High precision of Doehler-Jarvis make new cameras light-tight

Revere-made Wollensak "43" 8 M/M spool-type turret camera. Built-in filters provide finger-tip adjustment for three conditions: (1) clear shooting (2) haze (3) outdoor shots with indoor film.

Lights! Camera! Action . . .

Our hero (in darkroom above) has just snapped together the three die castings that house the new Revere-made home movie camera shown left . . . snapped them together around a tell-tale light.

The castings are raw . . . just as they come from Doehler-Jarvis. Notice no light escapes where the housing parts join. *Even before machining, the seal is light-tight.*

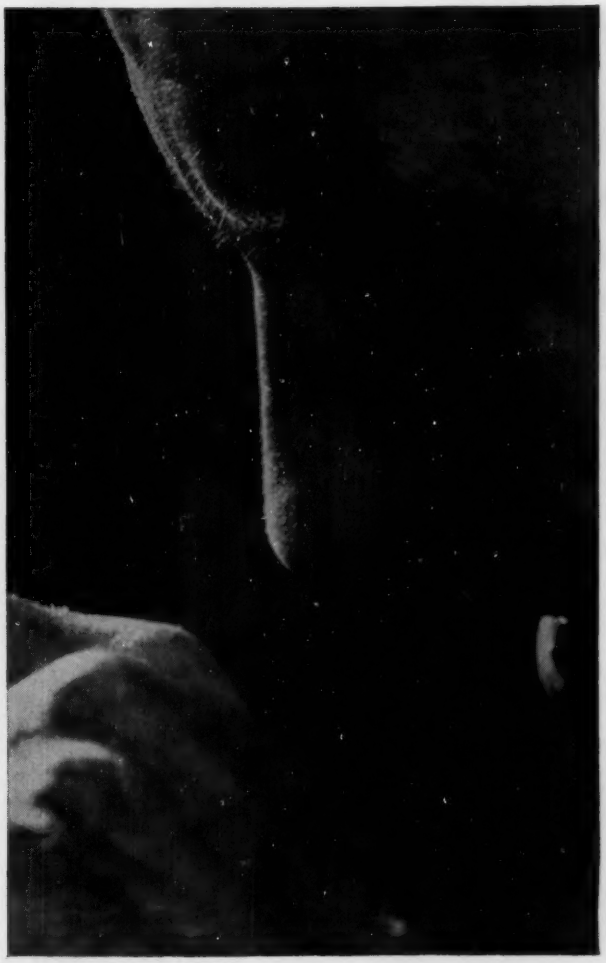
That's precision for you. The kind Revere Camera Company expects and gets from Doehler-Jarvis.

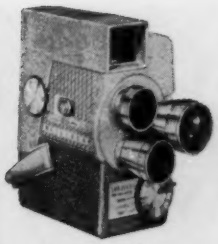
What's more, each casting provides, "no-tolerance" machining base points. From these points Revere establishes all basic dimensions for machining of the camera mechanism. They get an accuracy so high they can afford to offer a lifetime guarantee on the action.

Realizes many design advantages

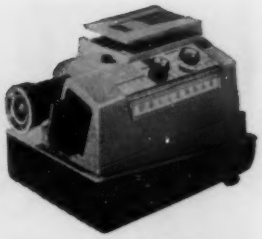
Revere designs from the start to take full advantage of die casting. In most models, for example, Doehler-Jarvis is called in while units are still in the hand sketch stage.

In this instance, details worked out include the use of lightweight magnesium; ways to reduce wall thicknesses (they're way thinner than ADCI minimums); location

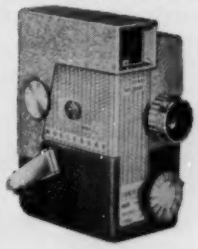




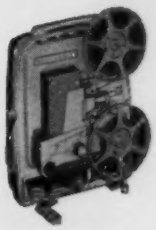
Wollensak "43"
8 MM Spool-type Turret Camera



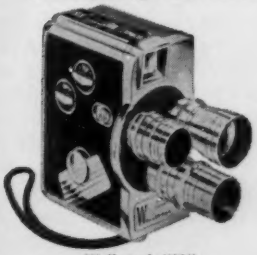
Wollensak "815"
Automatic Slide Projector, 2x2



Wollensak "42"
8 MM Spool-type Cine Camera



Wollensak "715" 8 MM
Movie Push-button Projector



Wollensak "23"
8 MM Magazine Turret Camera

Wollensak "16"
Stereo Camera

*Darkroom test illustrates precision of the raw Doehler-Jarvis die castings as received for use in the above Revere-made Wollensak cameras and equipment. Revere subjects the finished cameras to a much more severe 4-hour direct sunlight test. You can be *sure* they're light-tight.

fit so closely light doesn't pass..."

die castings helps Revere even before machining

of bosses, lugs, corner reliefs; extra back-up for stressed sections; tool-ups for machining and finishing; interchangeability between this and other models. All this pushes ultimate costs down, quality up.

Net result is an outstanding camera that is proving itself on the sales counter.

Doehler-Jarvis die-casts parts for all Revere-made cameras and projectors, not only their name line, but also Wollensak and other brands. Asked why they prefer die castings made by Doehler-Jarvis, Revere put it very simply: "rejects almost zero" . . . "likewise salvage" . . . "D and J people live with our jobs".

Right now Doehler-Jarvis people are "living with" the jobs of some 1400 major users of die castings. They'll do the same for you.

Doehler-Jarvis
DIVISION OF NATIONAL LEAD COMPANY
General Offices: Toledo 1, Ohio

In Canada:
Barber Die Casting Co. Limited
Hamilton, Ontario

Circle 450 on page 19

Quick-Opening Fasteners: Screw Type or 1/4 Turn?

Know the features of each before you specify.

M. R. TUOZZO

The selection of a quick-operating door fastener usually involves a choice between two basic designs; the quick-acting screw fastener and the ¼ turn fastener. Both are relatively inexpensive. Each has advantages that make it the logical choice for certain applications.

THE SCREW FASTENER is a rugged, square threaded screw assembly engaging in a special heavy stamped nut. The nut is clipped, riveted, or welded to the door frame. A special washer behind the thread captivates the screw in an oversize hole in the door.

Because of its exceptional "float," it is installed without precision measurements and will always line up with ease. Where a variation in material thickness may occur or a gasket must be compressed, the screw fastener is preferred, since a single grip length can be used throughout. Under most conditions it will completely disengage in two to four turns. It offers excellent resistance to vibration and forms a solid joint with no "give."

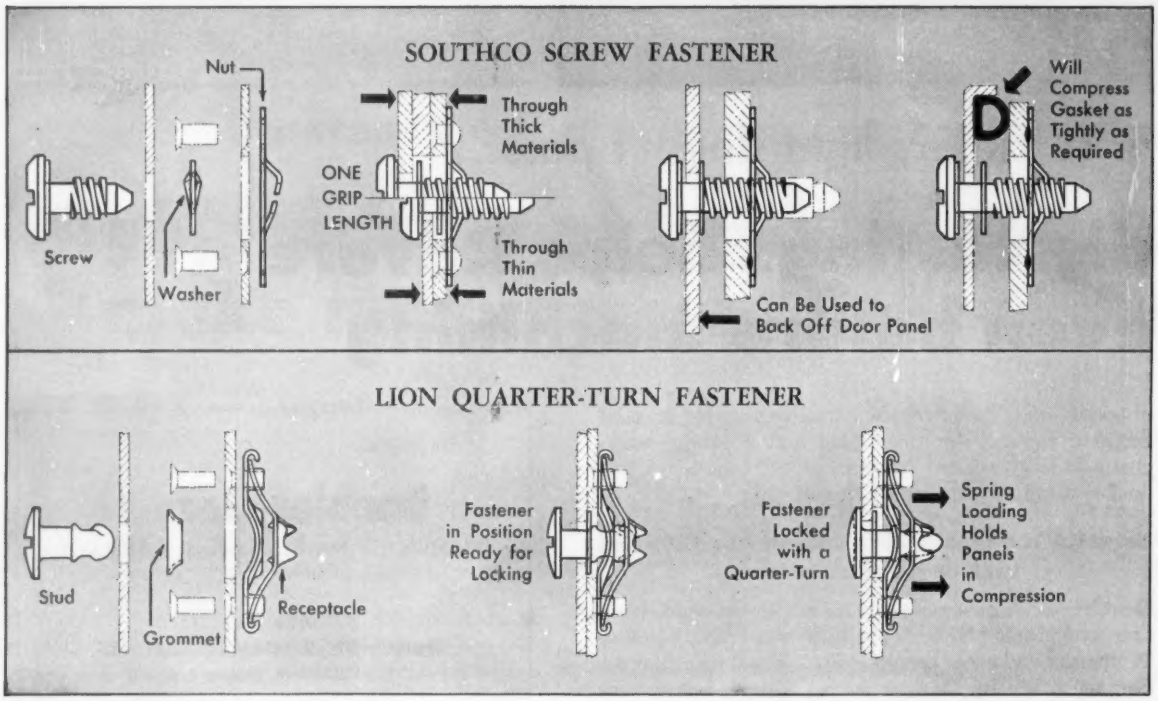
The screw fastener can be backed all the way out of the door frame without moving the door. If required, it can be installed so as to jack the door open as it is unscrewed.

THE QUARTER-TURN FASTENER is usually selected for application on aircraft (under Army-Navy-Air Force specification MIL-F-5591A) where instantaneous removal of fastened parts is required. As the name implies, it is quickly locked or unlocked by a fractional turn.

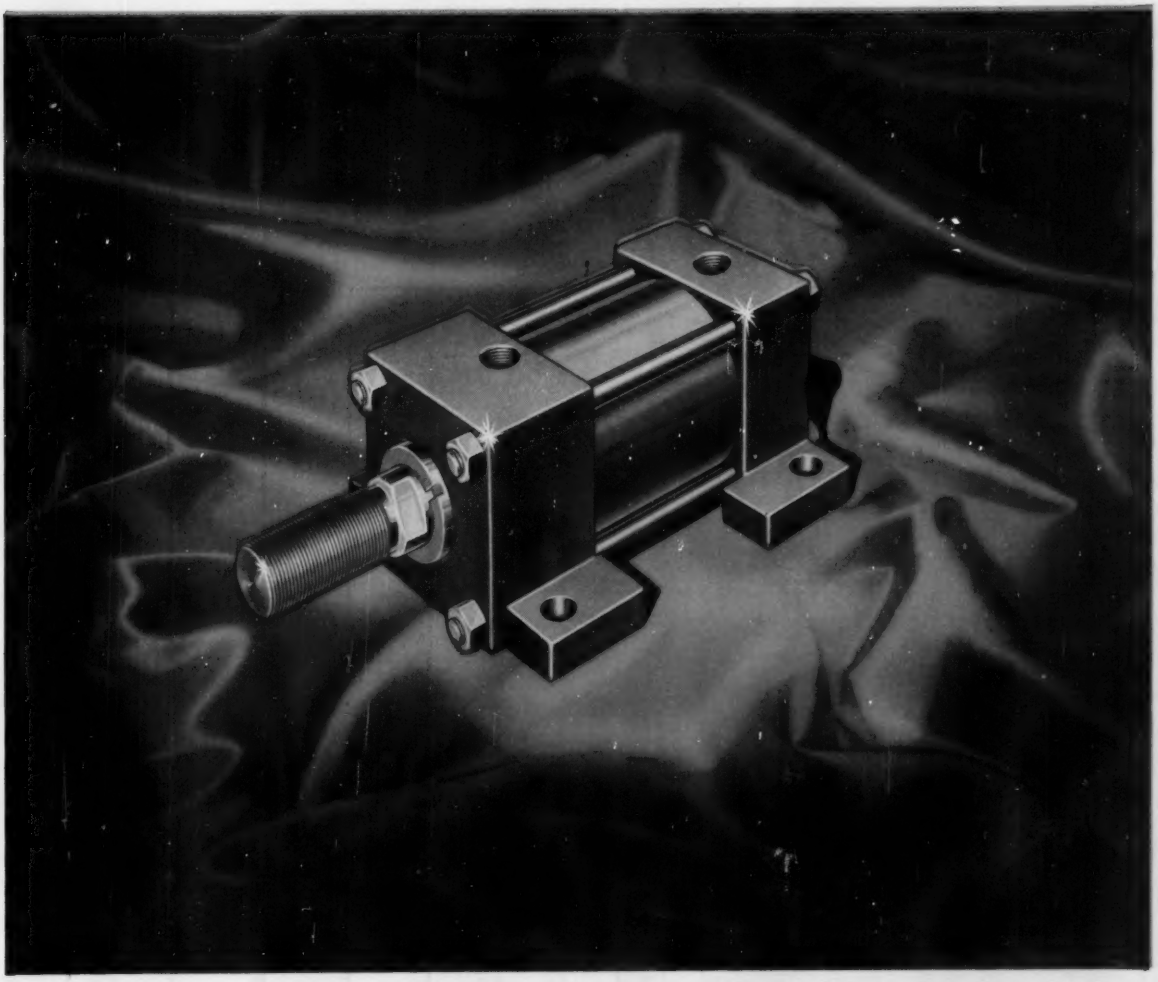
Its strength characteristics also are very high when the stud is formed from a single piece and no thin springs, wires, or cross pins exist in the assembly. The stud is retained in the door panel by a metal grommet, and engages in a full floating spring-loaded receptacle, riveted or welded to the door frame.

Where the thickness of door and frame are fairly constant through an entire production run, the quarter-turn fastener is a wise choice. Its design affords maximum speed in fastening, and excellent vibration resistance.

COMPARISON OF STANDARD QUICK-OPENING FASTENERS



SOUTHCO FASTENERS
LION
©1956
Southco Div., South Chester Corporation
237 Industrial Highway, Lester, Pa.



Illustrated—Logan Super-Matic Cylinder Meets J.I.C. Standards

Look to Logan

the ultimate in hydraulic cylinder design

FREE **SEND FOR THE "LOGAN CALCULATOR"**

MEMBER: Natl. Mach. Tool Builders' Assn.; Natl. Fluid Power Assn.

LOGANSPORT MACHINE CO., INC.
811 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

- ☐ 100-1 AIR CYLINDERS
- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
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- ☐ 51 PRESSES
- ☐ FACTS OF LIFE
- ☐ 62 SURE-FLOW PUMPS
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 and 200-7 HYD. VALVES
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- ☐ 70-1 CHUCKS
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- ☐ CIRCUIT RIDER

TO:

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COMPANY _____

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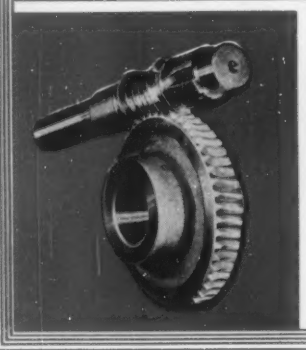
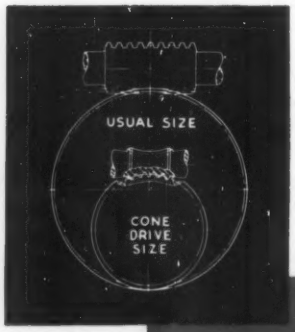
Circle 452 on page 19

for concentrated power





. . . CONE-DRIVE gearing has no equal.

You can pass an amazing amount of power through a set of Cone-Drive gears.

Want to cut product size? Cone-Drive will give you a more compact gear train with reserve load capacity.

Want to boost power output and hold size? That's easy with Cone-Drive gears. They'll carry two, three, and four times the load of cylindrical worm gearing.

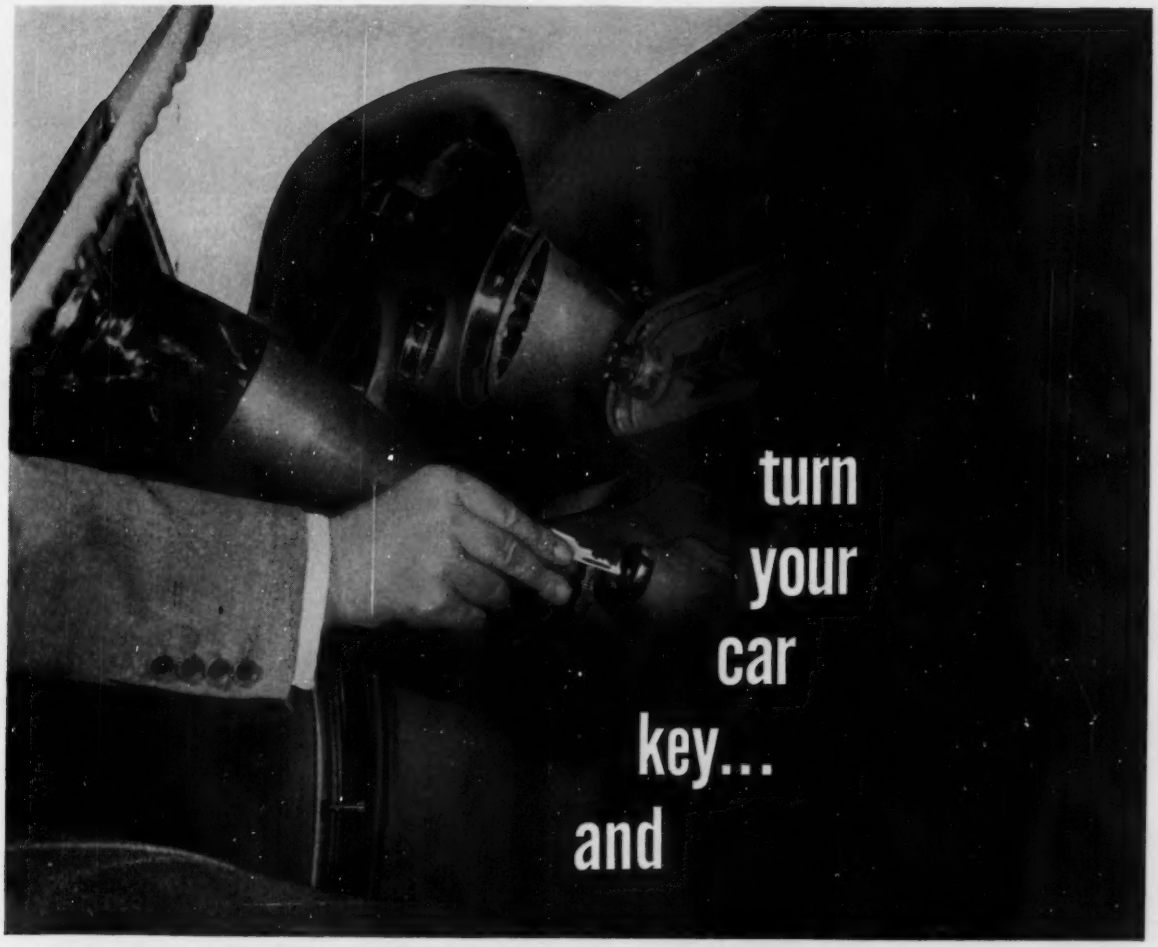
Why? In Cone-Drive gears, the load isn't concentrated on a small area per tooth or on just one or two teeth at a time. Cone-Drive's exclusive double-enveloping principle distributes the load over a lot of teeth and over more area on each tooth.

It cuts the unit loading the same way a pair of snowshoes supports a heavy man.

Ask for Bulletin CD-400 for complete details.

CONE-DRIVE GEARS
Division, Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 12, Michigan

Circle 453 on page 19



Synthane laminated plastics report for work

Breaker Arms for tractors and outboard motors are cut from lengths of molded laminated. Breaker arm bushings and rubber angles are important ignition components.

A turn of the ignition key and the thousands of parts which make up your car go to work as a team. Under the dash or under the hood are dozens of parts made of Synthane laminated plastics. They may seem insignificant but they're as necessary as an owner's license.

Take away Synthane laminated plastics and you have a car that won't start, a generator that won't run, lights that won't light, or a silent radio or motionless fan—which may give you some idea of the importance of a product like Synthane in the automotive industry.

Synthane laminates are excellent electrical insulators—they resist moisture—smile at oil—are easy to machine and mechanically strong. Synthane laminated plastics are available in sheets, rods and tubes or as parts completely fabricated to your designs and specifications.

For more information about the many properties of Synthane laminated plastics and how you can benefit by using Synthane materials and fabricating services, write for our latest product catalog. Synthane Corporation, 5 River Road, Oaks, Pa.

EASILY MACHINED

DIELECTRIC STRENGTH

OIL RESISTANCE

DIMENSIONAL STABILITY

SYNTHANE ... industry's unseen essential.

SYNTHANE CORPORATION, 5 RIVER ROAD, OAKS, PA.

Circle 454 on page 19

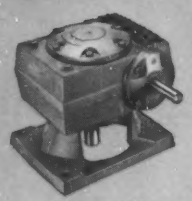
WHY PAY MORE
for specials, when you can get what you need FROM STOCK?

Design around
BOSTON Gear
100 SERIES
SPEED REDUCERS
1605
types and ratios
FROM STOCK

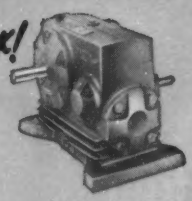
Horizontal Right Angle Drive
Worm Gear over

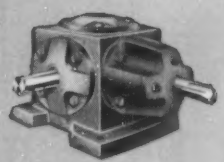
Horizontal Right Angle Drive
Worm Gear under

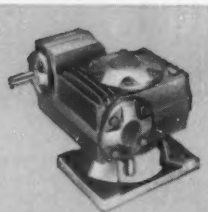
REDUCTORS Ratios 1:1 to 3600:1 — .004 to 50 HP


Vertical Right
Angle Drive

FROM STOCK!

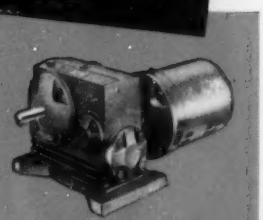

Double Reduction
Horizontal Parallel Drive


Horizontal Right
Angle Drive

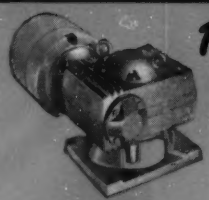

Double Reduction
Vertical Right Angle Drive

And now MORE SIZES in small REDUCTORS

Horizontal Right
Angle Drive


Double Reduction
Horizontal Parallel Drive

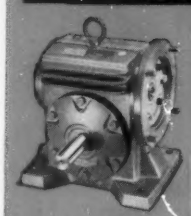
RATIOMOTORS Output RPM .49 to 175


Vertical Right
Angle Drive

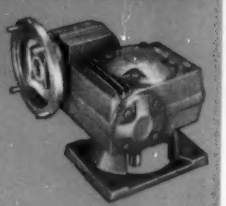
FROM STOCK!

Double Reduction
Vertical Right Angle Drive

All Ratiomotors also sold without motors as
FLANGED REDUCTORS



FROM STOCK!



You buy and attach your choice of motor

Meet increasing needs for smaller units in Horizontal Right Angle Drive models. Boston Gear Works, 64 Hayward St., Quincy 71, Mass.

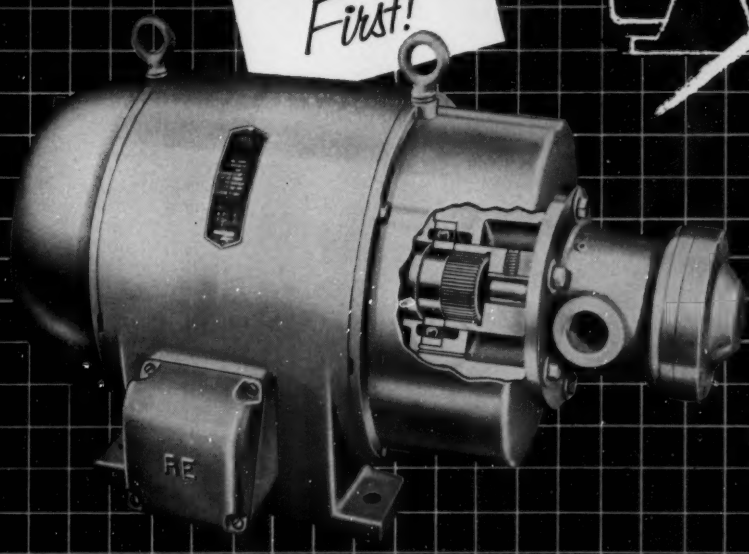
Catalog No. 56
lists full specifications, includes 50 pages of engineering data to aid in selection and application.

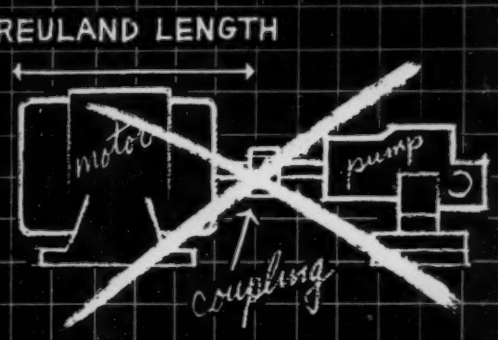
CALL YOUR BOSTON Gear DISTRIBUTOR

For nearest Distributor, look under "GEARS" in the Yellow Pages of your Telephone Book

57BG-RR-31

Another REULAND First!





- NO PLATFORM TO BUILD
- MUCH SHORTER LENGTH
- AUTOMATIC, PERFECT ALIGNMENT
- 30 H.P. 2½" SHORTER THAN FORMER 15 H.P. MODEL

NEW, REULAND HYDRAULIC PUMP MOTOR features FAST, SPLINE-COUPLED hook-up!

Perfect alignment ...in 1/10th ordinary time

You can hook up a Reuland motor and any standard make hydraulic pump in a matter of only seconds. All you have to do is slip the spline coupling onto the motor's spline shaft and attach the pump flange to the endbell.

Absolutely perfect alignment is assured. There is no tinkering around with a mounting platform and your finished job always has a sleek, well-designed appearance. Takes only a tiny fraction of the ordinary time.

For all standard pumps

Regardless of the pump you are now using, you can adopt this exclusive new Reuland hook-up. If your pump is not a standard make we can quickly adapt to your setup. The Reuland method is so radically simple you will be amazed at the tremendous advantages.

Coupling supplied with motor

Buy a Reuland hydraulic pump motor and you need nothing more. Spline coupling and drilled-and-tapped endbell are supplied ready for immediate pump attachment. (Adaptable to either single or double end pump installations.)

Use these new Reuland motors and you will save platform mounting expense and alignment time. You achieve compactness and better looks *plus* longer pump life through factory engineered alignment. For FREE ENGINEERING LITERATURE please write for folder No. 1109.

Other Reuland firsts...

- MOTOR WITH INTERNAL FLUID COUPLING
- ALL-ALUMINUM MOTOR FRAMES
- "THROUGH-SHAFT" MAGNETIC DISC BRAKES
- FOOT MOUNTED MAGNETIC DISC BRAKE COMPLETE WITH BEARINGS AND SHAFT
- PRECISION MOTORS FOR MACHINE TOOLS

REULAND MOTORS

REULAND ELECTRIC COMPANY

Western Division: Alhambra 73, California • **Eastern Division:** Howell 73, Michigan

Distributors in all principal cities

Circle 456 on page 19

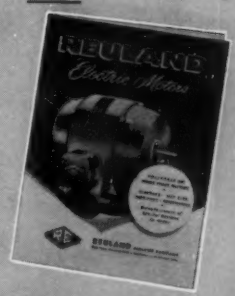
Don't pay for special-motor development before you check Reuland's

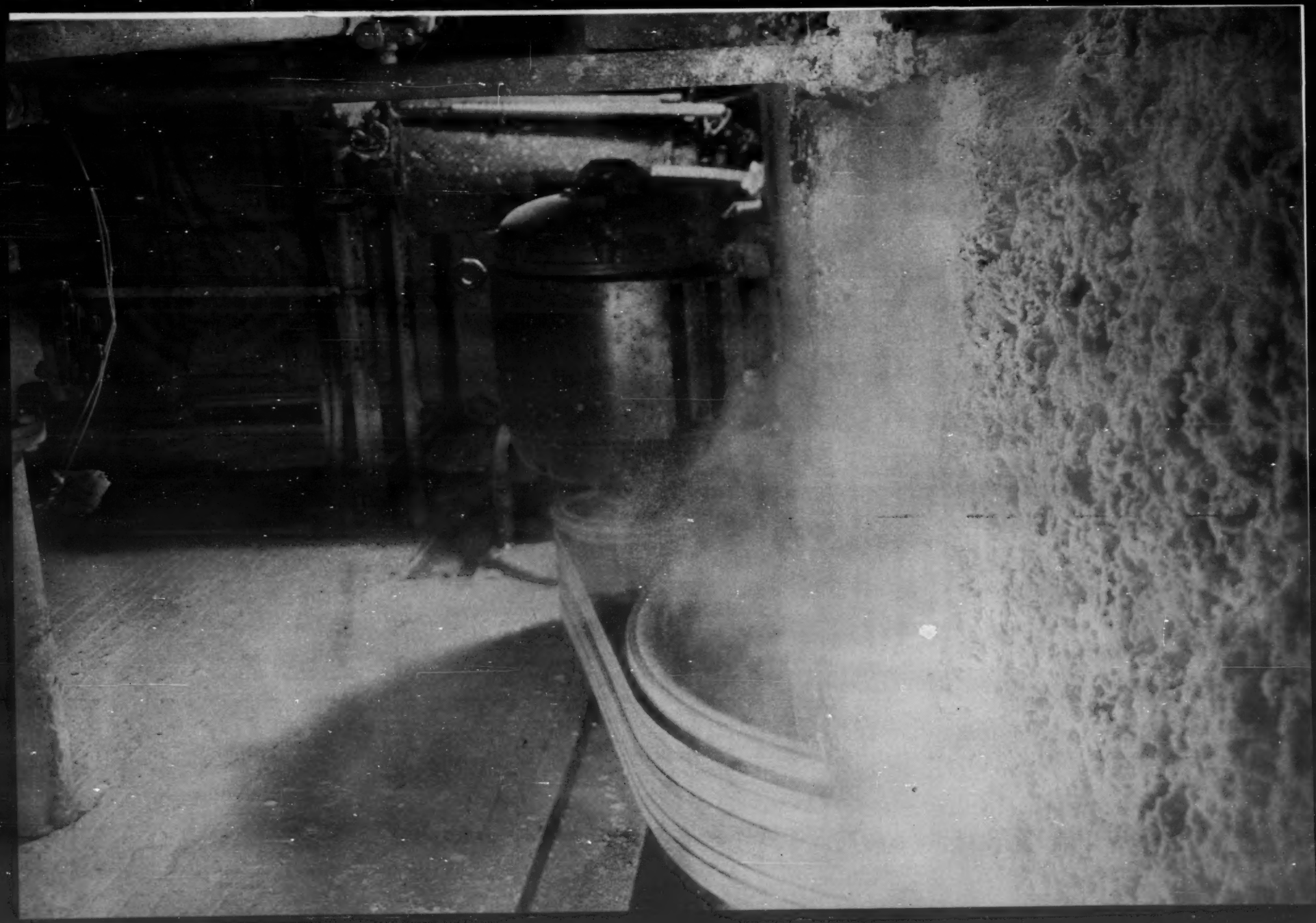
Special-Motor Library

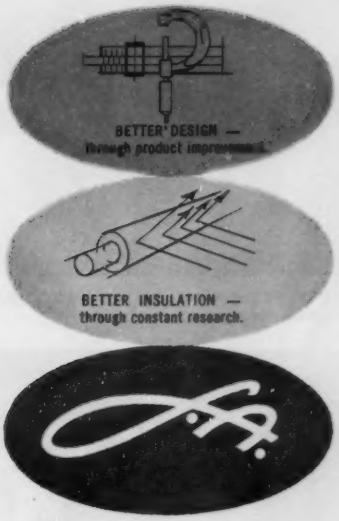
Hundreds of different and unique electric motors — one of which may already be made to order for your needs. Originally designed for special uses. Now available to help you save expensive development work and put you in production faster!

Write for free booklet on HOW TO USE the Reuland Library!

Free General Catalog of the COMPLETE Reuland Line of Standard and Special Motors sent on request







Moisture-laden hot-spot calls for some cool figuring!

Superior design of Louis Allis electric motors pays off under severe heat-humidity conditions

This paddle-agitator drive gets a steady bath of searing hot vapors from the trough below. Yet, the Louis Allis motor has given continuous and reliable service. Here are the special design techniques that make this possible:

Special attention to insulation—Louis Allis sponsors continuous research into new insulating materials. One example: Louis Allis engineers were first to combine Gilsonite with phenolics and alkyds. The result is a varnish with the highest degree of moisture, acid, and alkali resistance — extra-long life for all motor uses whatever your design problem.

Special care in manufacturing—Quality control of all materials . . . careful inspection . . . rigid test . . . all of these add up to the highest quality standards in the industry to assure you of continuous fine performance, dependability under any condition.

These and other Louis Allis extras—such as locked bearings for longer wear, positive lead identification for easier maintenance, and dynamically balanced rotor for quieter operation — could be the answer to your special design problems.

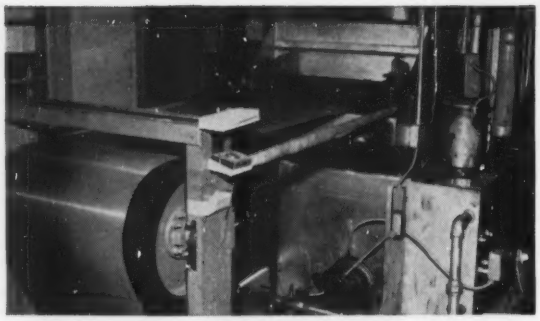
The complete story is in our Bulletin 1700. May we send it to you? Contact your nearby Louis Allis District Office or write The Louis Allis Company, 427 East Stewart Street, Milwaukee 1, Wisconsin.

LOUIS ALLIS

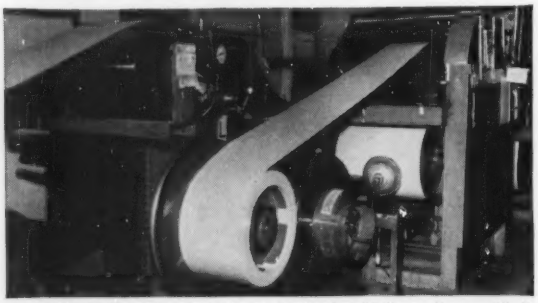
MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE-SPEED DRIVES

Circle 457 on page 19

LA-110



Strip emerges after its treatment with Bonderite, corrosion resistant paint bond.



Painted metal is slit to desired width and re-coiled as it emerges from finishing machine.

Re-coiled, finished metal is cut, formed, and inspected here. No loss of paint adhesion.

Painted stock is fed into punch press for blanking into various shapes and sizes.

Photos courtesy
Hastings Aluminum Products, Inc., Hastings, Michigan

Bonderized... Painted... Formed...

NO LOSS OF PAINT ADHESION!

Here's a production wrinkle that more and more manufacturers are using: Finish metal in the strip, then fabricate the product.

The technique applies equally well on steel and aluminum. First, run the strip through the Bonderite machine to produce the integral conversion coating that supplies a secure anchor for the paint. Next, run the Bonderized strip through roll-coat painting and the bake oven. The painted coils of metal are ready for fabrication, and the finish doesn't crack, chip or craze as it is formed, drilled, and punched.

Fabrication after painting, made possible by Bonderizing, saves money by reducing labor, handling and manufacturing area requirements, and allows higher production rates.

Write or call for more information on how you can finish before fabrication in your plant.

Bonderite, Bonderizing, Bonderized—Reg. U.S. Pat. Off.

PARKER RUST PROOF COMPANY
2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

Since 1914 — leader in the field

BONDERITE corrosion resistant paint base

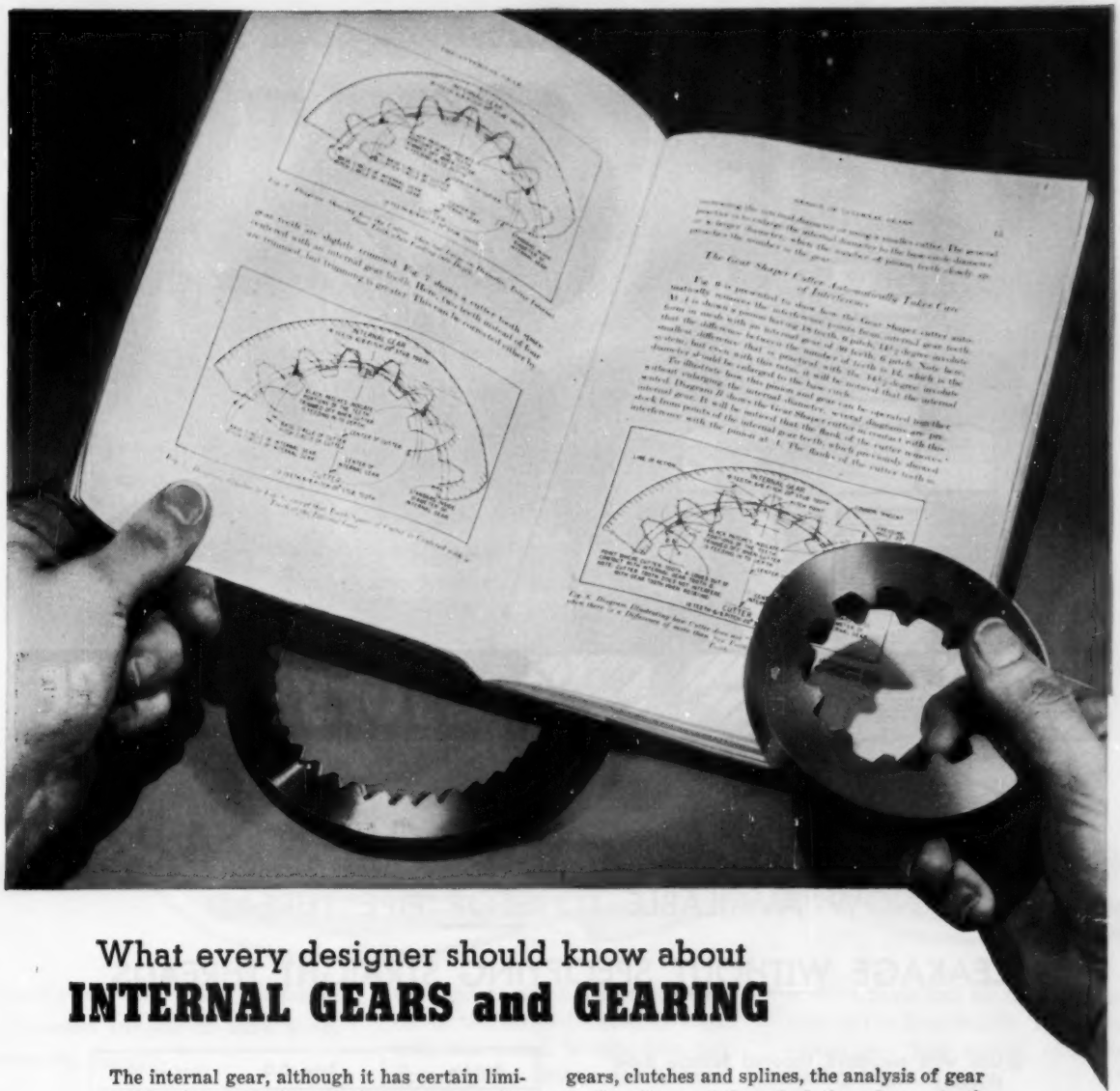
BONDERITE and BONDERLUBE aids in cold forming of metals

PARCO COMPOUND rust resistant

PARCO LUBRITE wear resistant for friction surfaces

TROPICAL heavy duty maintenance paints since 1883

Circle 458 on page 19



What every designer should know about
INTERNAL GEARS and GEARING

The internal gear, although it has certain limitations, has a number of advantages over the external gear, especially from the standpoint of compactness of design and more efficient tooth action. Most of the so-called limitations can be readily overcome by a proper understanding of the conditions to be met.

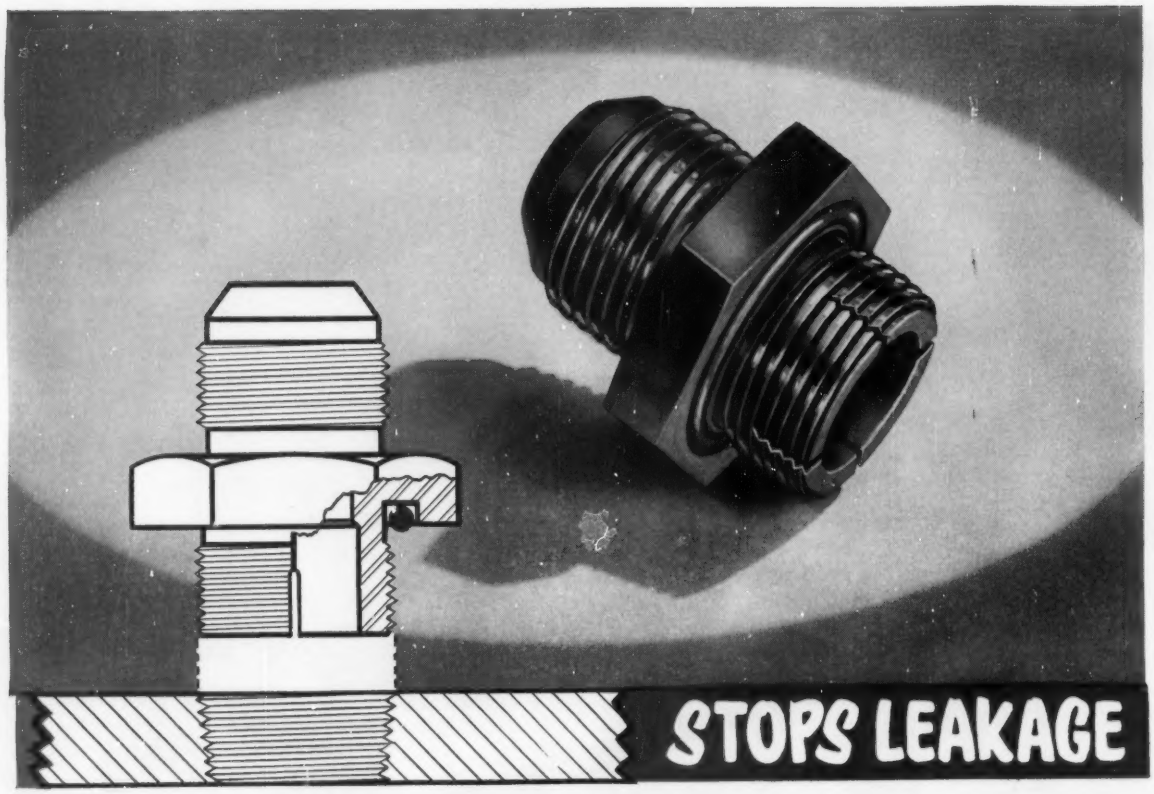
These advantages and limitations are explained in "The Internal Gear", a complete treatise on Internal Gear Design. This booklet contains information on the design and cutting of internal gears, clutches and splines, the analysis of gear tooth action and the calculation of gear tooth strength. Just write to any Fellows office for your copy.

Internal gears, as well as an almost unlimited variety of other internal contours, can be produced at low cost on Fellows Gear Shapers. In many cases the same Gear Shaper cutter can be used to cut both the internal gear and its mating pinion. Production is as simple as the production of external gears.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE **Fellows** *Gear Production Equipment*

Circle 459 on page 19



PETCH-HUPP *RING-WEDGE* ADAPTER

NOW AVAILABLE TO STOP PIPE THREAD LEAKAGE WITHOUT SPECIFYING STRAIGHT THREADS

- Use with standard tapered female pipe threads
- No special tools required
- Tube end utilizes standard 37° Flare fitting elements
- RING-WEDGE male thread slotted allowing O-ring seal contact independent of port thread depth
- O-ring does not interfere with threads
- O-ring seals on port boss-spot face optional — no pipe sealing compound required

Part No.	Tube O.D.	Used w/ NPTF
821RW 6	⅜"	¼"
821RW 6-6	⅜"	⅜"
821RW 8-4	½"	¼"
821RW 8	½"	⅜"
821RW 8-8	½"	½"
821RW 8-12	½"	¾"
821RW 10	⅝"	½"
821RW 12	¾"	¾"
821RW 14	⅞"	¾"
821RW 16	1"	1"
821RW 20	1¼"	1¼"
821RW 24	1½"	1½"
821RW 32	2"	2"

PETCH PMC

SALES—463 York, Detroit 2
PLANT—Alpena, Michigan

MANUFACTURING COMPANY

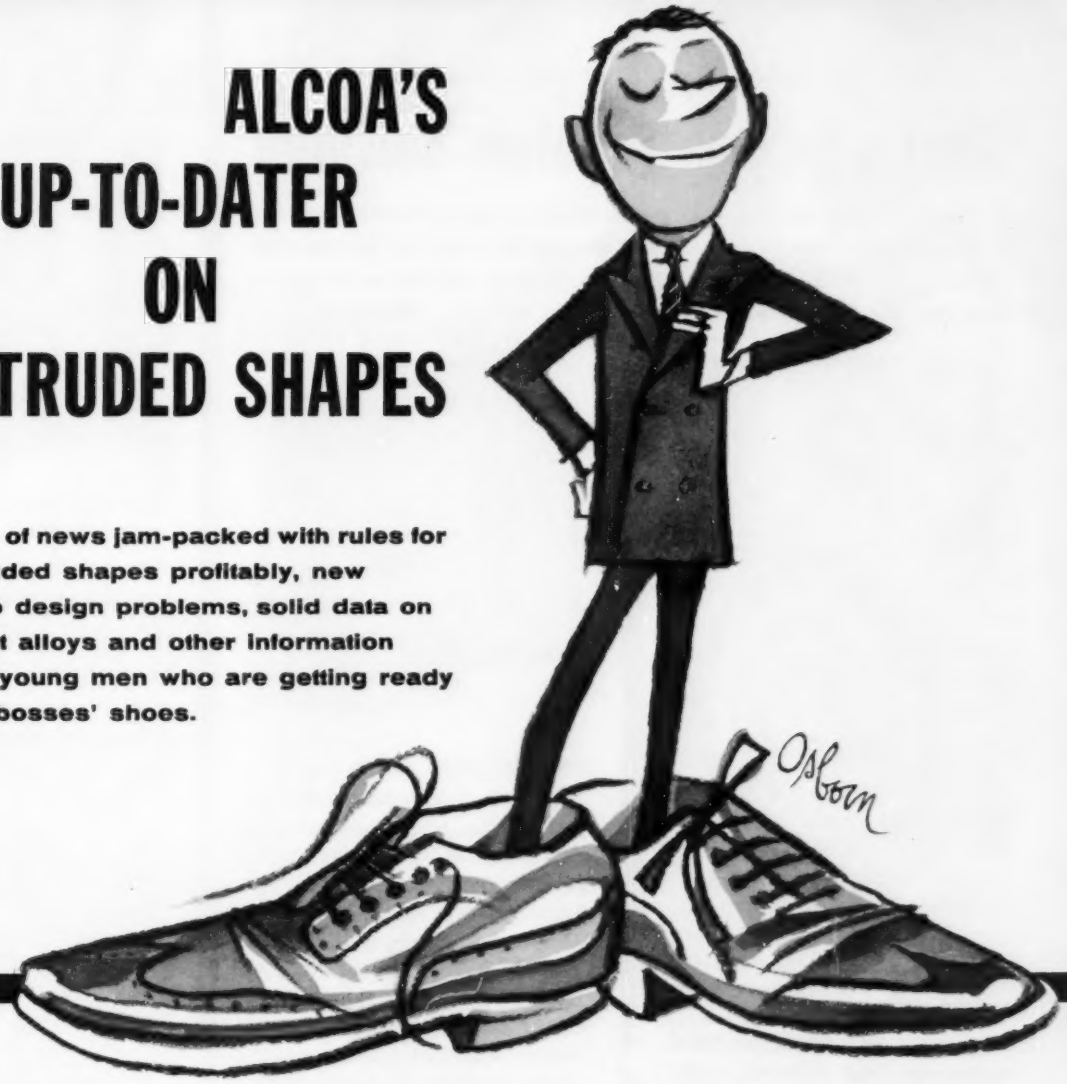
H57 10M 1056

Circle 460 on page 19

Circle 461 on page 19→

ALCOA'S UP-TO-DATER ON EXTRUDED SHAPES

Four pages of news jam-packed with rules for using extruded shapes profitably, new solutions to design problems, solid data on costs, latest alloys and other information for today's young men who are getting ready to fill their bosses' shoes.



here's the rule book for using extruded shapes to save time, trouble, money.

In a nutshell, the biggest rule is: when you have a complicated cross section, it can usually be made as an extruded shape—and much more economically. Then, too, an Alcoa® Extruded Shape adds strength without adding weight. It cuts out welding, roll forming, riveting and eliminates costly machining. Here's how:

1. Instead of using standard rolled shapes such as angles or I beams, consider a made-to-your-design extruded shape. It allows you to put the metal right where you want it and need it. Take a long column, for instance. An extruded shape with a cross section like a capital C will support almost twice the load as will a standard channel of the same dimensions—and with less metal. Weighs less, too. Frees your imagination from standard shapes.

2. If you're building up sections using welded, riveted or crimped construction, take a hard, cost-reducing look at extruded shapes. Eliminate cost-increasing assembly work, cut out the chance for human error, save the money spent for jigs or crimpers.

3. If you're machining bars or rod into special angles, T beams, or other special long shapes, extrusions can be far less costly. Time-killing, costly machining is gone—so is scrap generation.

4. If you've got a small part with a cross section that can be drawn in one plane, it can be extruded even if it's complicated. Lots of them can be made at one time in the long length. Then, the pieces are just sawed off, like slicing bread.

If you can doodle it, we can do it. If you can sketch the cross section, we can extrude it. All we need to start helping you is your sketch and invite.

if you can doodle it, we can do it.

advertisement

What's new in problem solving?

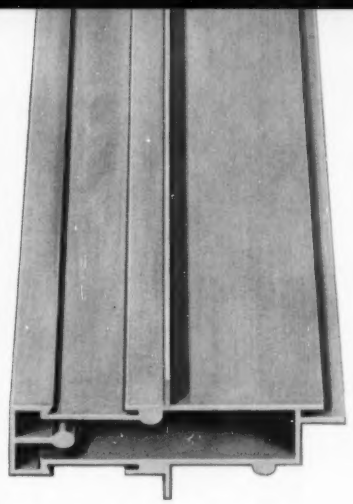
Virtually every shape extruded in our five extrusion plants is new—a problem solver to a designer and his company. Across the top of the page are a few recent examples that we think interesting. Use them as idea starters.

corkscrew extruded: spiral ribs

Here's an interesting extruded shape—a hollow tube with eight ribs spiraling down the outside. (We are making six- and 12-rib ones, too). It comes out in a long tube 20 feet long, six in. in dia. Alcoa's diemakers and extrusion experts worked it out so the extrusion actually spirals out of the die.

extruded sunshades

Here's another special architectural shape, used for louvers or sunshades that are electrically operated and clock controlled to follow the movement of the sun. They run vertically over window walls. Light weight, high reflectivity, beauty, natural resistance to weather, are reasons why aluminum is the metal. For economy, Alcoa extrudes in three pieces, which are dovetailed together during erection to make a louver 12 in. wide, 1½ in. thick. Walls are 0.063 in. thick.



complex extruded shape: special stool

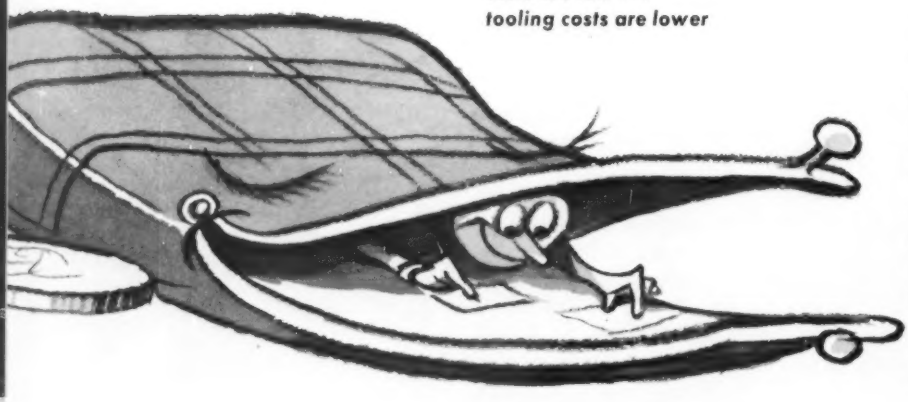
Typical of the many special architectural shapes is this special 5½-in.-wide "stool," a horizontal member used in a curtain wall building. Top slot takes the glass panel stop; bottom one, the aluminum panel stop. Inner key with knob is made with special tolerance of ± 0.005 in., takes fastener from vertical member. An extruded shape is the only practical way to make it. Bright, clean, rustproof Alcoa Extruded Shapes are universally used in building design. And color—an integral part of the metal surface—can be added. Maybe your shape isn't as complicated as this part, but we bet this example starts your imagination running.

Costs?....

When a designer turns to extruded shapes for the first time, he's sure costs are going up. Usually, he's looking at extrusions because he thinks his part would be impossible to make any other way—or because its costs are great in fabrication assembly. It's always a big, pleasant surprise when he finds out that base costs are low. Tooling for an extruded shape is usually less than it is for other fabrication methods—casting, forging, stamping, special roll forming, or full machining.

Die charges for average solid shapes: one fitting inside a 3-in. dia. circumscribing circle—a

costs are low . . . tooling costs are lower



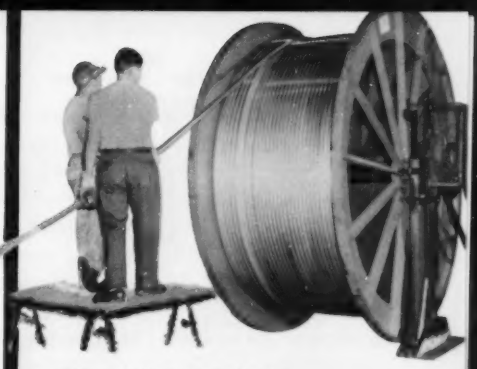
corner post: steel, 6¼ lbs/ft; aluminum, 2½ lbs/ft

Here's a special truck-body shape used as a vertical corner post. It replaces a formed steel post. In steel, it weighs 6¼ lbs / ft; rustproof Alcoa Aluminum Extruded Shape: 2½ lbs / ft. Cost and strength about the same. It's easier to handle during assembly. When used as roof rail, it is available in one long length. In steel, the forming tool limited the length, making welding necessary. Better check on the cost-reducing possibilities in your rolled steel forms. Many designers are turning to structurals extruded by Alcoa—reasons: rustproof, light, strong, available.

extruded 1,000 feet long

We're often asked how long and big an extrusion can be. 10-30 feet is usual, although that is often exceeded; 110 feet and more is possible.

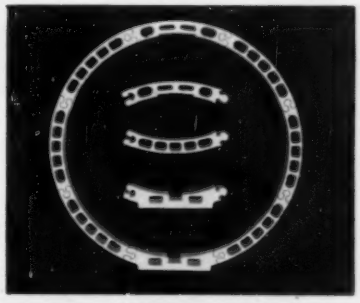
Here's an extra-long one, 1,000 feet. It's 2-in. dia. cable sheathing, continuously extruded by Alcoa in a piece almost 1/5 of a mile long. Alcoa research and improved manufacturing methods made it possible. It's coiled on big reels, shipped to the cable plant where it is drawn over the conductor. Replaces a lead application because of price, weight, availability, strength.



other idea sparkers

Other unusual extrusions that may spark an idea: wide integrally stiffened, ribbed panels that are extruded as a "V" configuration, then flattened and processed to make a wider panel than the presses could make. The 14,000-ton press makes pieces 40 in. wide by this method. Another reason for "V" construction: costs are partly dependent on the size of the circumscribing circle. Also a "V" shape can be made on a smaller press than would be needed if it was extruded flat. Dovetail, tongue and groove, shiplap, offset couplings, snap-fit joints are ways to multiply width without multiplying costs.

Alcoa often extrudes ribbed panels in narrow width components to cut costs and obtain thinner panel cross sections. Then they are roll-locked (up to 24 in. wide) prior to delivery. Shapes, extruded in sections to interlock with each other, are commonplace cost cutters in our plants. Here's a "for instance." Eight special shapes, 1½ in. thick, dovetail together to make a complex 20-ft tube, 23½ in. in dia.



Previously, it was made by rolled plate riveted up into an assembly. Cost, when made as Alcoa Extruded Shapes, was slashed tremendously.

...here's the factual story

little over $100; inside a 6-in. dia. circle—less than $400. Semihollow and hollow shapes run higher.

Other cost factors: shapes cost more as they get thinner; the further you go from a symmetrical shape, the higher the cost. Sometimes, the higher cost per pound of a thin section makes sense economically since the real cost is per foot or piece.

standard stocked shapes and dies

So far, we've been talking about special shapes to your designs, but that's not the whole picture. Alcoa maintains stocks of many standard shapes at its distributors around the country—angles, bars, channels, H beams, I beams, tees, zees, etc. Hence, shapes, with high mechanical properties and smooth, bright finish obtained by extruding, can be had quickly—and without die charges. Certain architectural, truck-body and aircraft shapes are also stocked at distributors. Also standard (without charge) dies are maintained at the plants and available for mill production. Information on stocked shapes and available dies is as close as your phone. Use it to call your Alcoa sales engineer.

advertisement

small parts...dozens at a time

Often, small parts with one-plane cross sections can be made cheaply by extruding long lengths and then wacking off the parts. They are just sliced off like bread. Torque converter blades are a good example. They have a special tolerance of ± .002 in. on the ordinates. Individual blades are cut off from long extrusions (they look like longitudinal slices of bent teardrops). Then they're tumbled, drilled and pin-installed on the stator or turbine. Previous metnod was milling from bar stock. Costs and scrap loss are cut.

what's new in alloys?

Biggest news is the availability of super-strength, hard alloys 7178 and X7079 for extruded shapes. Aircraft and missile designers are giving them their biggest play. Alloys 7178 and X7079 are a lot harder to extrude, a burden to the die designer . . . so costs are up. But so are the properties.

Here's a handy table of mechanical properties of the normal extrusion alloys in usual tempers. Where a range is given, properties depend on certain factors (thickness, area, etc.). To find out the properties possible with your design, check your Alcoa sales engineer. For any help on the proper alloy for your best balance between performance and costs, he is your great aid. Let him counsel with you.

Extrusion Alloys, Minimum Mechanical Properties

Alloy	Temper	Ultimate Strength psi	Yield Strength psi	Elongation % in 2"
3003	0	—	19,000	25
2014	0	18,000	30,000	12
	T4	35,000	50,000	12
	T6	53 to 58,000	60 to 68,000	6-7
2024	0	19,000	35,000	12
	T4	42 to 52,000	57 to 70,000	8-12
6061	0	16,000	22,000	16
	T4	16,000	26,000	16
	T6	35,000	38,000	10
6062	0	16,000	22,000	16
	T4	16,000	26,000	16
	T6	35,000	38,000	10
6063	T4	10,000 (1)	22,000 (1)	14 (1)
	T42	10,000 (1)	17,000 (1)	12 (1)
	T5	16,000 (1)	22,000 (1)	8 (1)
	T6	25,000 (1)	30,000 (1)	8-10 (1)
7075	0	24,000	40,000	10
	T6	68 of 72,000 (2)	78 to 80,000 (2)	6-7 (2)

(1) 0.500 in. and less, thickness
(2) 5.000 in. and less, thickness; maximum areas 32 sq in.

cry to the designer:
up performance,
down costs,
beat competition

straight talk

Today's big cry to the designer is: up performance, down costs, beat competition. Often, his answer lies in Alcoa Extruded Shapes. The way to start? Call your Alcoa sales engineer. He's listed under "Aluminum" in the Yellow Pages. He can contribute good, solid technical thinking at any stage of your project. The best time to call him in is at the "pre-drawing board" or "doodle" stage. Use him—that's his job.

He'll have a copy of the new booklet, *Alcoa Aluminum Extruded Shapes*, under his arm for you. It's packed full of technical data and tables to make your work lighter. If your work is in aircraft, involves really big extrusions, or extremely thin sections, he'll trot out your copy of Alcoa's new 36-page design book on the design horizons opened by the 14,000-ton press. Or write for your copy of either booklet; better yet, write for both. ALUMINUM COMPANY OF AMERICA, 1909-C Alcoa Building, Pittsburgh 19, Pa.

ALCOA ALUMINUM
EXTRUDED SHAPES
ALUMINUM COMPANY OF AMERICA

Your Guide to the Best in Aluminum Value

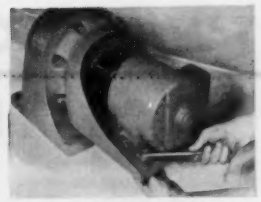
advertisement

Litho in U. S. A.

EFFICIENT NEW RUNNING MATE

for latest NEMA motor sizes . . .

LINK-BELT Motogear designed for bracket-mounting foot-type motors of any manufacturer



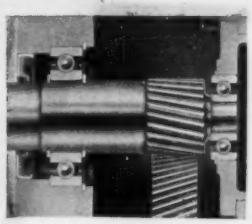
EASY MOTOR REPLACEMENT—Remove four mounting bolts and separate coupling. Oil drainage is unnecessary. Sturdy bracket design aids motor re-alignment.

ABILITY TO ACCOMMODATE A WIDE RANGE OF MOTORS meets emergencies, minimizes downtime.

Immediately available from stocks near you—new Link-Belt Motogears in sizes up to 60 hp, output speeds from 280 down to 6 rpm.

Wherever space is restricted . . . where downtime means a costly break in production continuity—Link-Belt Motogears soon pay their own way. In addition to easy motor replacement—simplified ratio changes and quick accessibility of parts for maintenance offer major service savings.

Contact your nearby Link-Belt office for facts. Ask, too, about the new flange-mounted Gearmotors stocked in sizes up to 30 hp. Or write for Book 2447, giving details of both.



RIGIDITY of high-speed shaft and pinion is provided by straddle-mounting — extremely important in coping with shock, reversing or heavy loads.

ONE LOW-SPEED GEAR SET per drive size and maximum accessibility of all operating parts simplify inspection, maintenance and ratio changes.

LINK-BELT

ENCLOSED DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,518

TWO MORE MANUFACTURERS TAKE OF THE EXTRA SALES VALUE OF

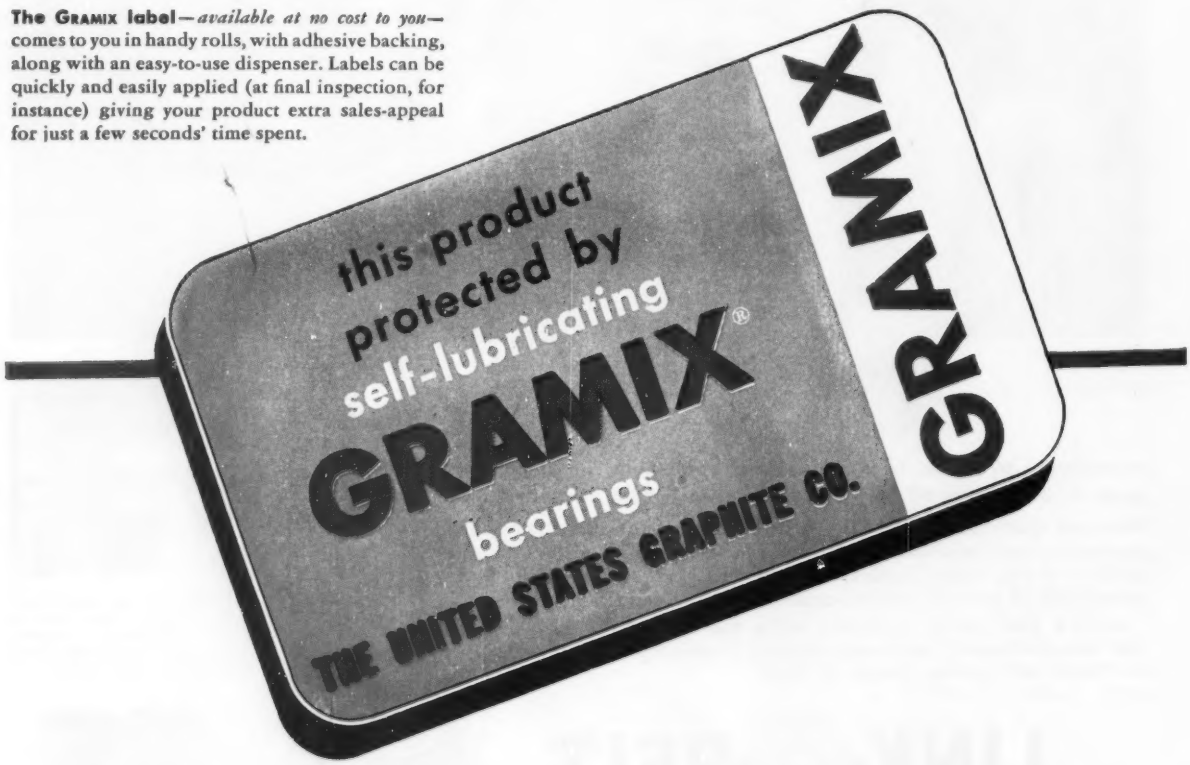
THE GRAMIX® LABEL

(PRODUCTS OF POWDER METALLURGY)

THE SIGN OF A QUALITY COMPONENT

The GRAMIX label, indicating that a product utilizes one or more GRAMIX parts or bearings, is helping to boost sales appeal at the point-of-purchase. This seal means that quality components are incorporated in the product. Every day GRAMIX parts are finding more and more applications. And for good reason: GRAMIX alloys have excellent bearing and mechanical properties. Because of their porosity, GRAMIX parts can be impregnated with oil during manufacture, to make them self-lubricating. GRAMIX bearings and parts are mechanically strong, durable and highly resistant to wear. GRAMIX parts are equal, and in many cases superior, to machined parts and can be produced in relatively intricate shapes with tolerances as close as .0003″. And best of all, GRAMIX parts are being produced at a fraction of the cost of forged or machined parts of similar design. It is likely that there is a place for GRAMIX in your products.

The GRAMIX label—*available at no cost to you*—comes to you in handy rolls, with adhesive backing, along with an easy-to-use dispenser. Labels can be quickly and easily applied (at final inspection, for instance) giving your product extra sales-appeal for just a few seconds' time spent.



THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® SINTERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

ADVANTAGE

Modern Eskimo fans, manufactured by the Bersted Manufacturing Division of McGraw Edison Company, Boonville, Missouri, are the result of many years' experience in the manufacture of efficient and dependable appliances. Eskimo fans spin on GRAMIX bearings and therefore operate hour-after-hour, day-after-day, and year-after-year without fail. Eskimo fans carry the GRAMIX label, for added sales appeal at the point-of-purchase. Write today for your copy of GRAMIX bulletin No. 21.

The Thor Speed Drill, produced by Speedway Manufacturing Company of Cicero, Ill. (Division of Thor Power Tool Company) gives professional performance yet sells at an "amateur" price. GRAMIX bearings help contribute to both the high performance and modest cost of these fine tools. The GRAMIX label assures the user that Speedway power tools are tools of dependability.

These GRAMIX self-aligning bearings are typical of the type being used in the Eskimo fans and Speedway drills.

Write today for this book. Engineering Bulletin No. 21 gives the full story on GRAMIX. Be sure to write for your copy.

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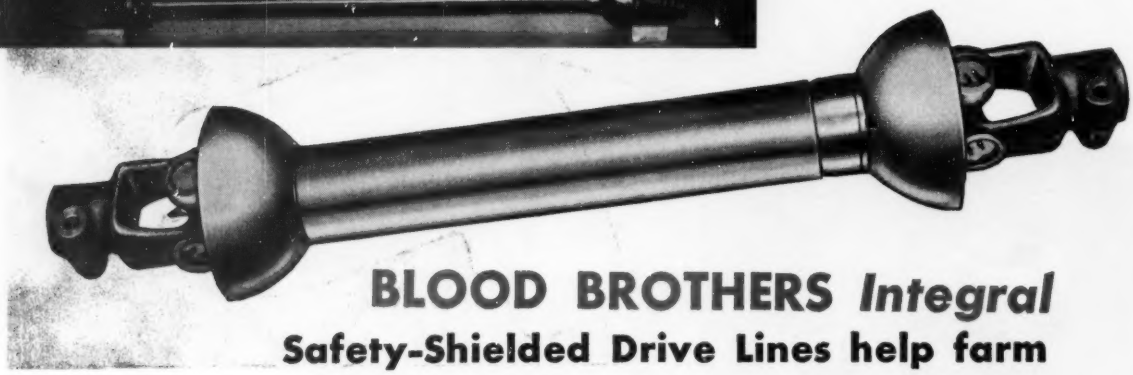
GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

Circle 463 on page 19

Farm implement dealers cooperated with the Watonwan County, Minn., Safety Council, to stress the dangers of unguarded power take-off shafts in this county fair exhibit. "Empty chairs" mean "empty tractor seats" too!

Photo courtesy of
Watonwan County Safety Council



BLOOD BROTHERS *Integral*

Safety-Shielded Drive Lines help farm implement dealers keep their customers safe!

For humanitarian reasons—and wise business practice as well—it pays to increase the customer's safety in every possible way. As proof of great progress in the farm implement field, Blood Brothers reports an increase of over 300% in the demand for Integral Safety-Shielded Drive Lines during the past year alone!

Some manufacturers are supplying Integral-Shielded Drives exclusively on *all* power take-off implements they build. This trend to greater safety helps implement builders—dealers—users—everyone!

Saleswise, Blood Brothers Integral-Shielded Drive Lines are helpful too. They offer a strong "plus" selling feature that *proves* you place the farmer's best interests *foremost.* Designed to avoid careless or absent-minded removal, they'll be *in place* to protect implement operators at all times.

If you *build* implements, write for information on the sizes you need.

FOR FARM IMPLEMENTS, MORE BLOOD BROTHERS UNIVERSAL JOINTS ARE USED THAN ALL OTHER MAKES COMBINED

BLOOD BROTHERS
MACHINE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
ALLEGAN, MICHIGAN

UNIVERSAL JOINTS
AND DRIVE LINE
ASSEMBLIES

Change motors in minutes—

with FALK *all-steel* MOTOREDUCERS

No long and costly "down time" involved

Motors can be interchanged or replaced *in minutes* with the all-steel, All-Motor type FALK Motoreducer. No long and costly "down time" is involved in making the change!

Best of all, replacement is not limited to original make of motor—new NEMA frames may be substituted for old. This versatile Motoreducer operates with any make, speed or type of standard foot-mounted motor within its AGMA rating. No modification, no special shaft, no "partial" motor required.

In addition to unmatched motor interchangeability, this dependable gear drive—the "work horse of industry"—offers: widest choice of output-shaft position (horizontal, vertical, right-angle)...any output-shaft connection...any mounting, including wall and ceiling...standard speed range from 1.5 rpm to 1430 rpm. All these advantages, plus proved efficiency, low maintenance and extra-long life, make the All-Motor type FALK Motoreducer your best buy for any job requirement.

Furnished in sizes up to 75 hp with any make, style or type of motor; or, *without a motor if desired.* FALK Motoreducers are available from convenient factory, field or distributor stocks, from coast to coast.

Write for Bulletin 3100

THE FALK CORPORATION, MILWAUKEE, WISCONSIN

MANUFACTURERS OF:

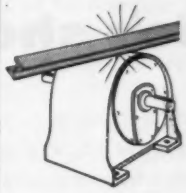
- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

FALK

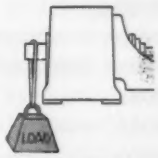
...a good name in industry

Circle 465 on page 19

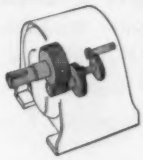
FALK "IN-BUILT" FACTORS assure full dependability—better service—longer life



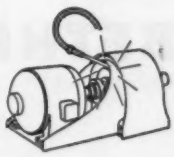
ALL-STEEL HOUSINGS
Rugged, strong, rigid ...all parts heavy steel plate, formed and welded in the Falk Weld Shop.



LARGE OVERHUNG LOAD CAPACITY
Large shafts, oversize bearings...rigid mountings with wide bearing spans to handle maximum loads.



PRECISION GEARING
Heat-treated alloy steel gearing, precision cut and shaved after heat treatment to eliminate distortion.



SEALED HOUSINGS
Splashproof, dustproof, oiltight. Dual closures and one-way vents keep oil in, dust and moisture out.

He's shooting for perfection

This earnest young man is intent on turning out a perfect sheave. From the looks of the job, we'd say his chances are fine. Best-looking sheave wheel we've seen in quite a while.

He has done his machining with great care, and with complete confidence. That confidence is warranted, for the wheel was first a Bethlehem steel blank, made by Bethlehem's forging-and-rolling process.

If you've never seen this method of manufacture, let us explain it briefly. It employs a mill that is the only one of its kind in the entire country. Blanks are not just forged, not just rolled, but *both*—in a single operation that produces high strength and very desirable grain flow.

That high strength is important. Equally important is the way the blanks machine. In the customer's shop, machinists can do their job with assurance, knowing that the metal underneath is as firm and "sweet" as that on top.

Bethlehem forged-and-rolled blanks are available for a long list of applications, including spur, bevel, miter, and other types of gears; crane and sheave wheels; turbine rotors, clutch drums, brake drums, flywheels, pipe flanges, and numerous others. You can obtain the blanks in sizes from 10 to 42 in. OD, untreated or heat-treated. For full details, ask for Booklet 216; it will be sent to you promptly.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

DU PONT

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA
ON THESE VERSATILE ENGINEERING MATERIALS
"ZYTEL," "ALATHON," "TEFLON," LUCITE"

Dial faces of LUCITE® molded with integral hairline cut production costs

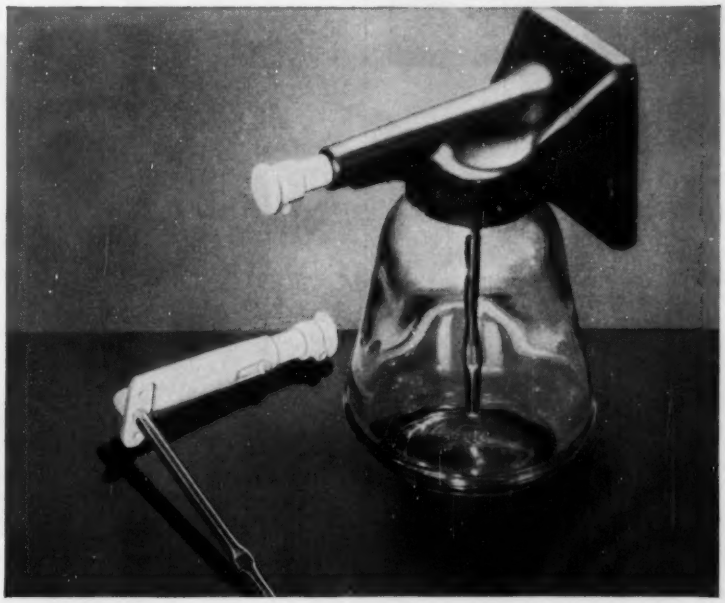
The precision with which Du Pont LUCITE acrylic resin can be fabricated is demonstrated by this hairline molded into one surface of a potentiometer dial face. The hairline is a half-round recess transferred directly from the die. The dial face replaces an assembly having a soldered wire hairline and a glass window, at a saving of $1.80 per unit. The parts made of LUCITE are economical to fabricate and withstand shock.

LUCITE offers outstanding transparency, transmitting about 92% of impinging light. LUCITE also has the ability to "pipe" light. In this instance, the clear LUCITE of the dial face transmits the "darkness" of the encasing black panel to the hairline, so that it is unnecessary to fill the hairline with black paint. The dial faces have been in service for more than two years with satisfactory results.

LUCITE is available in a wide range of sparkling, non-fading colors. It is shatterproof, light in weight, and resistant to weathering and many chemicals. LUCITE is fabricated economically by injection- or compression-molding, or extrusion. Du Pont LUCITE may be able to solve a design problem for you, particularly where high-grade optical qualities are required. Clip the coupon for more information about LUCITE acrylic resin.

This portable potentiometer, employed as a millivolt indicator, is manufactured by Leeds & Northrup Company, Philadelphia, Pennsylvania. Inset shows dial face of Du Pont LUCITE acrylic resin used in the instrument.

Precision molded parts of ZYTEL® can eliminate costly machining operations



"Likwidurn" soap dispenser manufactured by American Dispenser Company, Inc., New York, New York. Replacement of stainless-steel parts in valve assembly with parts of ZYTEL nylon resin afford substantial cost reductions.

Parts of ZYTEL nylon resin feature a high degree of durability, a low coefficient of friction, and good chemical resistance. Products molded of Du Pont ZYTEL are tough and strong, even in thin sections. They have excellent form stability at temperatures as high as 250°F. Cost savings are possible in many applications because components of ZYTEL usually require no secondary finishing. Frequently, a single part molded of Du Pont ZYTEL can replace an entire complex assembly.

The "Likwidurn" soap dispenser, shown above, is designed to deliver a measured amount of liquid soap at each stroke of the valve. Accurate fit of the valve parts is essential to assure proper operation. The valve must also remain unaffected by the concentrated soap solution.

ZYTEL nylon resin was chosen for this application, because it is economical to mass-produce parts injection-molded to close tolerances, which need no further finishing. The use of ZYTEL eliminates machining of the stainless steel, effecting substantial savings in manufacturing costs. In addition, the weight of the unit is reduced.

Evaluate ZYTEL in terms of your own design needs. Property and application data are available without obligation.

OVER

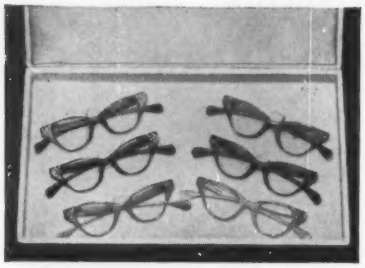
Circle 467 on page 19

DU PONT

Better Things for Better Living . . . through Chemistry

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

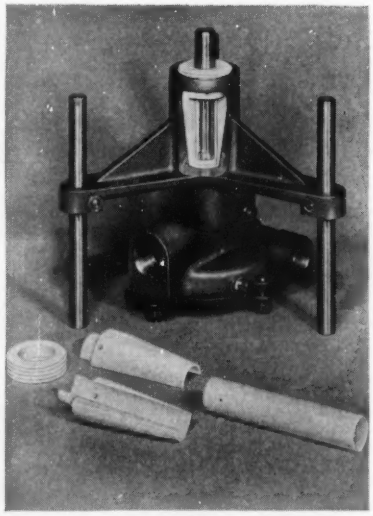


NYLAIRE – frames of ZYTEL® feature exceptional strength . . . attractiveness

Styled eyeglass frames of ZYTEL nylon resin withstand hard usage without breaking, combine attractive design with durability. ZYTEL can be molded in colors, so frames are offered in a selection of 34 permanent shades.

Fashion-conscious purchasers are pleased by smoothness, resiliency, and light weight of ZYTEL. Du Pont ZYTEL is distinguished by its toughness, form stability, and chemical resistance. These eyeglass frames are one interesting application of ZYTEL, which utilizes a number of the properties of this versatile engineering material. The use of ZYTEL may solve a design problem for you. *(Nylaire* eyeglass frames are manufactured by *Limited Editions, Inc., Linden, New Jersey.)*

High-speed bearing of TEFLON® resists corrosive attack, needs no lubrication



Cutaway portion of submersible pump shows bearing assembly of durable TEFLON tetrafluoroethylene resin. Assembly consists of shaft sleeve, tapered bearing, and lock nut. (The pump shown above is manufactured by ECO Engineering Company, Newark, New Jersey.)

A new bearing assembly of TEFLON tetrafluoroethylene resin has greatly broadened the range of applications of this chemical sump pump.

Due to the inherent surface "slipperiness" of TEFLON (kinetic coefficient of friction of only .04), no auxiliary lubrication of the bearing is necessary. Contamination of pharmaceuticals and sensitive materials by contact with lubricants is therefore prevented.

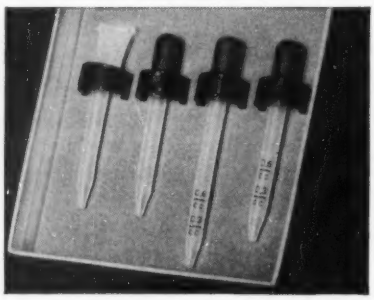
TEFLON is tough and durable. This permits the pump bearing to withstand high radial and tangential stresses at speeds of 3,540 rpm or higher for extended periods of time. The bearing is capable of continuous operation in the presence of product suspensoids and foreign abrasive matter such as tank scale. Bearings of TEFLON permit either chemical or steam sterilization.

Du Pont TEFLON tetrafluoroethylene resin has outstanding chemical inertness. This engineering material is not affected by aqua regia or other acids. Alkalies in any concentration do not react with it. TEFLON is inert to nearly all chemicals and solvents normally used in commercial practice. Exceptions to this include attack by the alkali metals under certain conditions. At elevated temperatures and pressures, halogens and certain halogenated chemicals and solvents may affect TEFLON.

Du Pont TEFLON offers a distinctive combination of mechanical, electrical, and chemical properties. Use of TEFLON has frequently resulted in more efficient, economical, and compact designs. In your applications, too, TEFLON may be the means of economizing on materials and costs or solving a tough design problem. For more details on how TEFLON can help you, clip and mail this coupon.

DROPPERS ARE UNBREAKABLE

Medicine droppers with unbreakable pipettes made of ALATHON® polyethylene resin give a regulated-size droplet. Lines can be printed on the pipette to indicate dosage. Smooth, highly transparent ALATHON reduces danger of injury to delicate tissues from accidental movements. (Made by PharmaPlastics, Inc., Baltimore, Maryland.)



E. I. DU PONT DE NEMOURS & CO. (Inc.), POLYCHEMICALS DEPARTMENT
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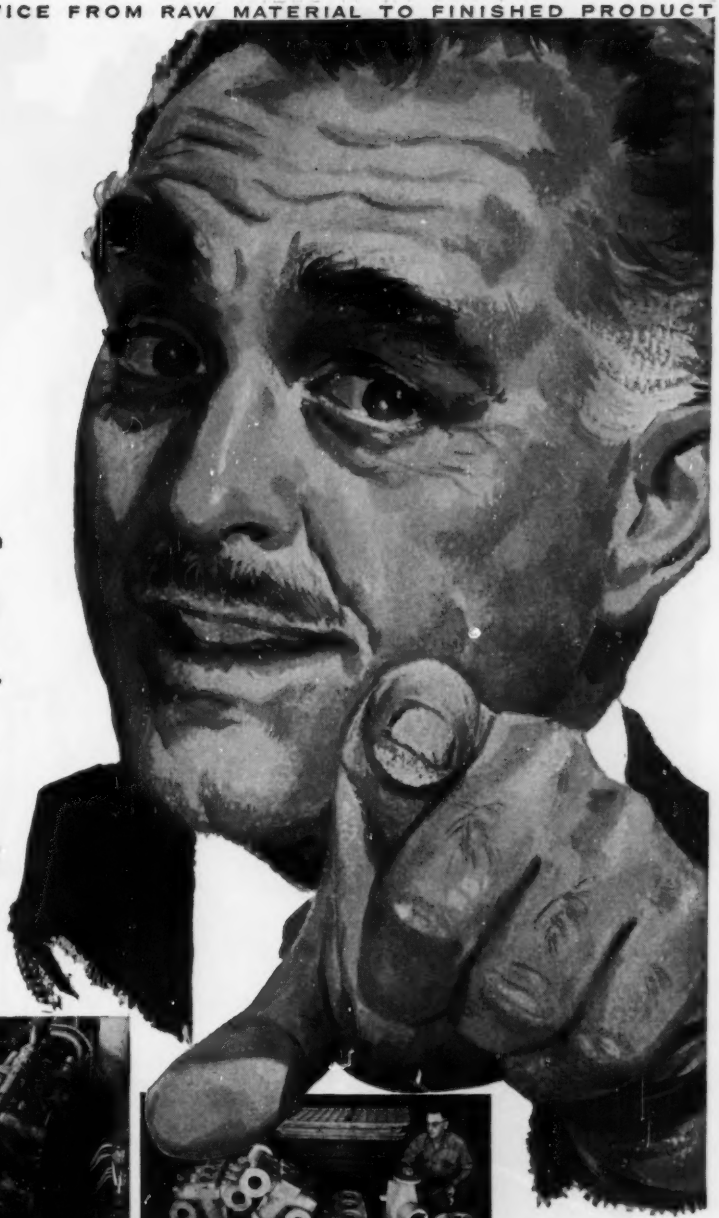
Circle 468 on page 19

AMPCO — ONE-SOURCE SERVICE FROM RAW MATERIAL TO FINISHED PRODUCT

You're the boss when you design with Ampco Alloys



You're not limited to a single copper-base alloy or a single form

Your design behaves the way you want it to, after it takes shape in one of more than 100 Ampco alloys.

Why? Because whether you are looking for resistance to wear, impact, fatigue, or corrosion, Ampco has a tailor-made alloy to meet your requirements.

And besides, you have flexibility in selecting the most economical form of production. Why? Because Ampco is available in sand-cast, centrifugally-cast, shell-molded, precision-cast, fabricated, forged, extruded, and sheet and plate forms. A call to your nearby Ampco field engineer will get you an unbiased recommendation.

Write for Bulletin 33 describing the Ampco Metal series of alloys.

Ampco's one-source service includes production-run machining of Ampco copper-base alloys to the quality standards of the aircraft industry.

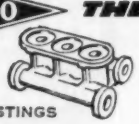
2,275-ton hydraulic press in Ampco's modern, laboratory-controlled mill for extruding rods, bars, hollow rounds, and shapes.

Meter housings and fluid ends. Ampco produces sand castings like these up to 14,000 pounds — and centrifugal castings up to five tons.

AMPCO METAL, INC. Dept. MD-3 Milwaukee 46, Wisconsin • West Coast Plant: Burbank, California

AMPCO® **THE METAL WITHOUT AN EQUAL**

CAST-TO-SIZE CASTINGS



SAND CASTINGS

CENTRIFUGAL CASTINGS

FABRICATIONS

FORGINGS

SHELL-MOLDED CASTINGS

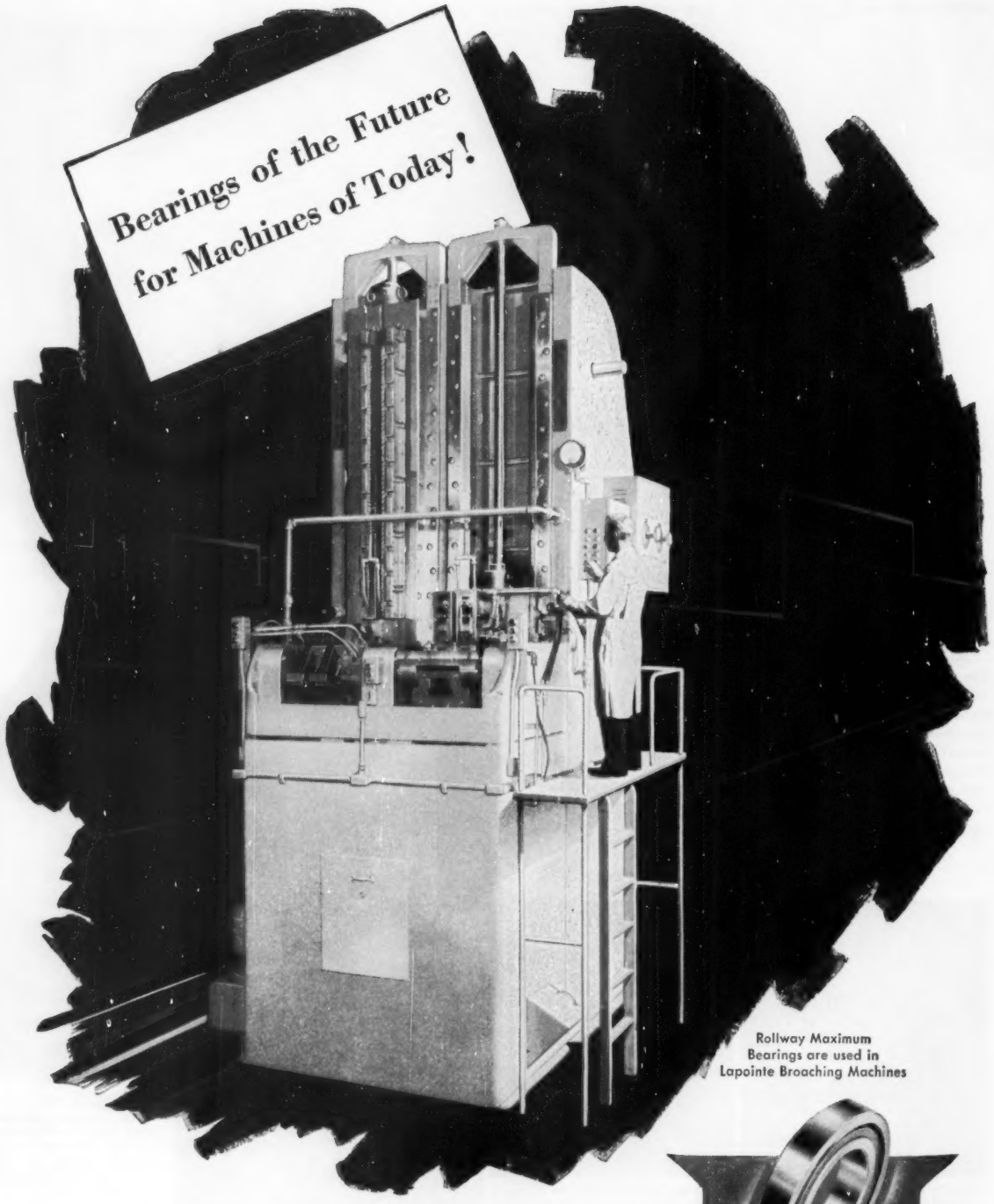
EXTRUSIONS

SHEET AND PLATE

MACHINED PARTS

D-53.

Bearings of the Future for Machines of Today!



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Rollway roller bearings regularly offer performance capabilities for more than the needs of today. They are continuously anticipating the operating requirements of years ahead.

Wherever bearing precision and load values are important in your plant or products – for original equipment or replacement service – call on Rollway *bearings of the future,* to give you the utmost performance in your machines of today. Rollway Bearing Company, Inc., 549 Seymour Street, Syracuse 4, N. Y. Manufacturers of a complete line of radial and thrust cylindrical roller bearings.

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Maximum
ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Milwaukee • Seattle • Houston • Philadelphia • Los Angeles • San Francisco

Wherever your machinery is shipped...

the performance and the name are the same around the world!

FOR YEARS SHELL TELLUS OIL has been top-rated as both a lubricant and a control fluid for complex hydraulic systems. Its ability to combat foaming, oxidation, rust, sludge-formation and wear has earned it nation-wide popularity.

You may be glad to know that the equipment you manufacture can get the same efficient protection in foreign countries. Tellus* Oil is available to your foreign customers from near-by points. It will be the same Tellus Oil that your domestic customers rely upon. Write Shell Oil Company, 50 West 50th St., New York 20, New York, or 100 Bush Street, San Francisco 6, California.

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Machinery manufacturers:

Your customers abroad will receive the same Shell Tellus Oil that your domestic customers enjoy. And this same uniformity applies to

SHELL TURBO OIL—gives anti-wear lubrication for utility, industrial and marine turbines

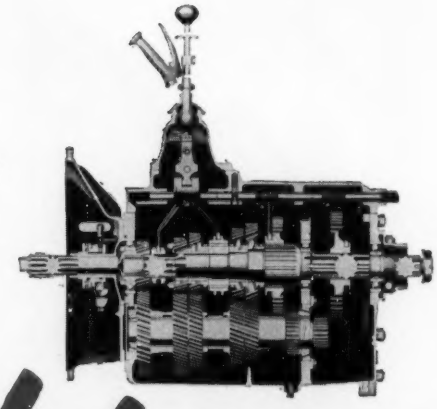
SHELL ALVANIA GREASE—multi-purpose industrial grease, and a complete line of other

SHELL INDUSTRIAL LUBRICANTS

SHELL TELLUS OIL

SHELL

Model R-35



A NEW Lighter 7

in a compact package . . . for having up to 400 cu. in. of piston

Now, all the advantages of the big, rugged, service-tried-and-tested Fuller ROADRANGER Transmissions are packaged for the first time in this smaller, new R-35 ROADRANGER Transmission. This 7-speed ROADRANGER is designed to provide drivers of smaller trucks and tractors with the same positive ROADRANGER control—the same ease of shifting provided by the larger ROADRANGERS.

With the R-35 ROADRANGER, shifts are simple, short, fast. Yet the driver has 7 forward speeds available in progressive and selective steps, with closely spaced and equal ratios in the operating range. The 7 forward speeds, and 1 reverse, are shifted by a single lever—there is no gear splitting. It is a *unit* transmission with 7 speeds—there is no auxiliary section.

Regardless of time, traffic and terrain, the Fuller R-35 ROADRANGER Transmission gives the driver *immediate and complete control* of every operating situation.

Owners and operators can *now* specify the R-35 ROADRANGER Transmission. They can now obtain the same results provided by the larger ROADRANGER Transmissions . . . faster trip time, lower fuel consumption, longer engine life, less driver fatigue. For complete details, check with your truck dealer today, or write Fuller Manufacturing Company.

RATIOS

Gear	Standard*	Optional**	% Step
Seventh . .	1.00	1.00	
Sixth	1.33	1.24	*33 24**
Fifth	1.794	1.67	34.8
Fourth . . .	2.416	2.25	34.8
Third	3.298	3.06	36.5
Second . .	4.90	4.55	48.6
First	8.20	7.62	67.3
Reverse . .	7.63	7.09	67.3

Weight . . . . . 375 lbs.

Oil Capacity . . . 16 pts.

- **No gear splitting—7 selective and progressive gear ratios**
- **Easier, quicker shifts—closely spaced and equal ratios in the operating range**
- **One shift lever controls all 7 forward and 1 reverse speeds**
- **Engines work in peak hp range with greater fuel economy**
- **Less driver fatigue—⅓ less shifting**
- **Compact unit transmission—only 375 lbs., approximately 26 25/32 inches in length**

FULLER MANUFACTURING COMPANY, *Transmission Division*, Kalamazoo, Michigan

SPEED ROADRANGER®

gasoline engines
displacement

Fuller TRANSMISSIONS

Circle 472 on page 19

AUTOMATIC *Air-Borne* LUBRICATION

FOR ALL ELEMENTS OF A MACHINE

One Lubricator Per Machine — Model 33AL-4 (½") Lubrication Unit automatically creates finely divided air-borne oil fog. Completely lubricates a machine having a maximum requirement of 100 bearing inches.

Better Lubrication — Continuously applies protective film of fresh oil to lubrication points. Never periods of too much or too little lubrication.

Compact, Complete, Attractive — Measuring only 6-1/32" x 6-1/32" x 5-3/16", cabinet contains air filter, pressure regulator, MICRO-FOG Lubricator.

Visual Oil Feed — Oil feed is readily visible, providing positive proof of lubrication. No guesswork.

For complete information on MICRO-FOG Lubrication for all bearing inch requirements, call your nearby Norgren Representative listed in the telephone directory — or WRITE FOR FACTORY LITERATURE.

MICRO-FOG by Norgren

C. A. NORGREN CO.

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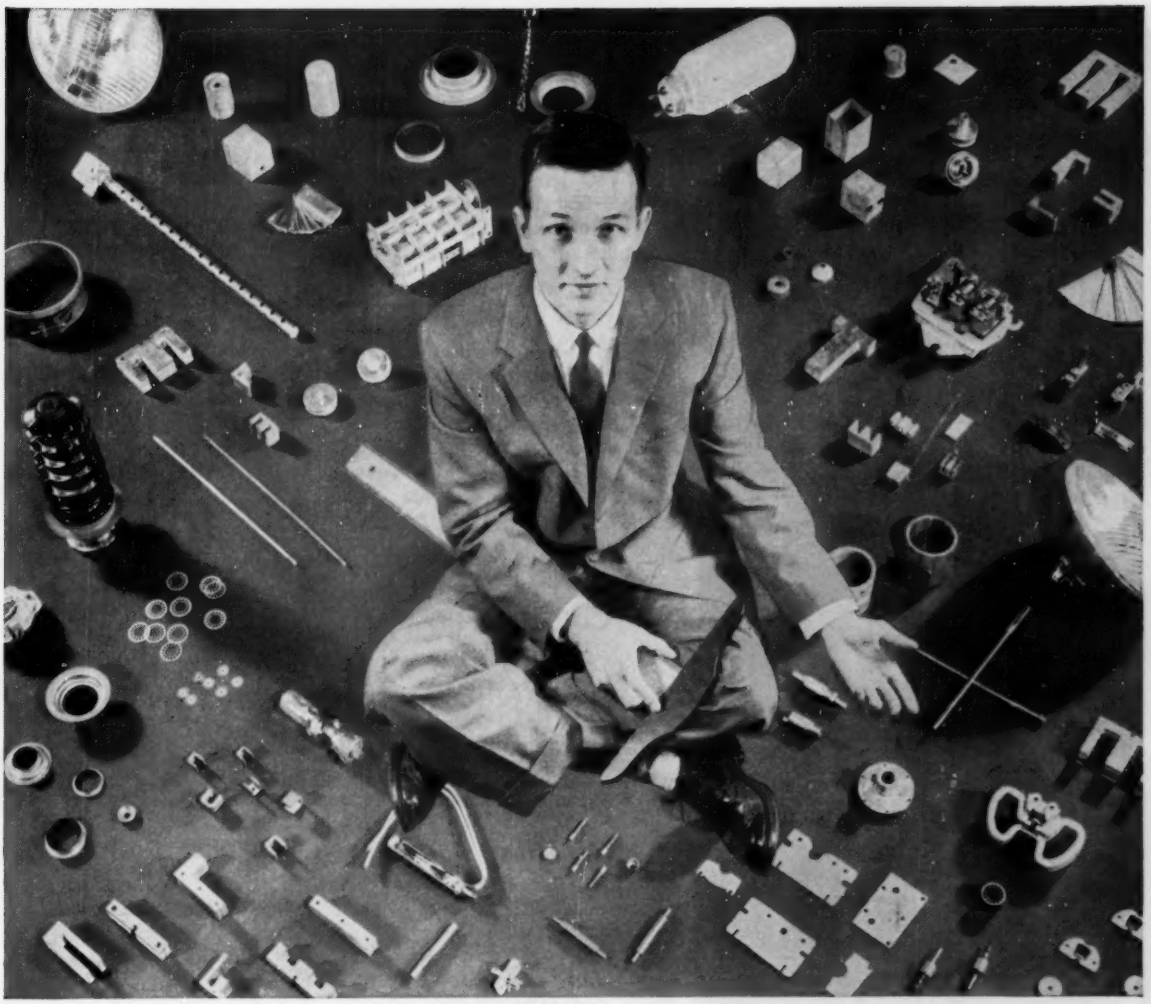

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Complete information on Carpenter High Nickel Alloys is contained in the most authoritative and useful set of booklets ever published on this type of alloys. We'll be glad to see that you get the data you need if you'll drop us a line on your Company letterhead.

Remarkable temperature compensation, controlled low expansion, high permeability, predictable response to very weak electrical signals, improved glass-to-metal sealing are here today.

In miniaturization, instrumentation, electronics . . . wherever the push is on to make products smaller, lighter, more accurate . . . new challenges are being met every day by Carpenter High Nickel Alloys.

Today, Carpenter has the most complete line of proven alloys available for these specialized applications. Let's discuss their part in your present and future NOW!

Carpenter STEEL

high nickel alloys

The Carpenter Steel Company, 120 W. Bern St., Reading, Pa.
Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

WEIGHT TABLE

Dia. or Distance Across Flats	Decimal Equivalent	Shape—Pounds per Linear Foot			
		Aluminum Alloy 2011*		Brass	
		Round	Hexagon	Round	Hexagon
1/16"	.0625	.0037	.0042	.0113	.0125
5/64"	.0781	.0058	.0066	.0177	.0195
3/32"	.0938	.0084	.0106	.0254	.0280
7/64"	.109	.0114	.0143	.0346	.0382
1/8"	.125	.0151	.0164	.0452	.0499
9/64"	.141	.0189	.0209	.0572	.0631
5/32"	.1563	.0234	.0258	.0706	.0779
11/64"	.172	.0283	.0312	.0855	.0943
3/16"	.188	.0337	.0372	.102	.112
13/64"	.203	.0396	.0434	.119	.132
7/32"	.219	.0460	.0505	.138	.153
15/64"	.234	.0526	.0576	.159	.175
1/4"	.250	.0600	.0656	.181	.199
17/64"	.266	.0677	.0743	.204	.225
9/32"	.281	.0759	.0836	.229	.252
19/64"	.297	.0846	.0934	.255	.281
5/16"	.312	.0937	.1030	.283	.312
21/64"	.328	.1034	.1138	.312	.344
11/32"	.344	.1134	.1248	.342	.377
23/64"	.359	.1239	.1359	.374	.412
3/8"	.375	.1349	.1488	.407	.449
25/64"	.391	.1466	.1618	.441	.487
13/32"	.406	.1582	.1746	.478	.527
27/64"	.422	.1709	.1886	.515	.568
7/16"	.438	.1837	.2026	.554	.611
29/64"	.453	.1965	.2167	.594	.655
15/32"	.469	.2109	.2324	.636	.701
31/64"	.484	.2246	.2475	.679	.749
1/2"	.500	.2398	.2648	.723	.798
17/32"	.531	.2707	.2987	.817	.901
9/16"	.562	.3036	.3348	.915	1.01
19/32"	.594	.3383	.3730	1.02	1.13
5/8"	.625	.3748	.4133	1.13	1.25
21/32"	.656	.4132	.4557	1.25	1.37
11/16"	.688	.4535	.5002	1.37	1.51
23/32"	.719	.4958	.5466	1.49	1.65
3/4"	.750	.5398	.5951	1.63	1.80
25/32"	.781	.5856	.6458	1.77	1.95
13/16"	.812	.6335	.6985	1.91	2.11
27/32"	.844	.6832	.7528	2.06	2.27
7/8"	.875	.7347	.8100	2.22	2.44
29/32"	.906	.7880	.8684	2.38	2.62
15/16"	.938	.8434	.9288	2.54	2.80
31/32"	.969	.9006	.9925	2.72	2.99
1"	1.	.9596	1.150	2.89	3.19
1 1/16"	1.0625	1.082	1.193	3.27	3.60
1 1/8"	1.125	1.214	1.337	3.66	4.04
1 3/16"	1.187	1.353	1.490	4.08	4.50
1 1/4"	1.250	1.498	1.650	4.52	4.99
1 5/16"	1.312	1.653	1.820	4.98	5.50
1 3/8"	1.375	1.814	1.998	5.47	6.03
1 7/16"	1.438	1.982	2.184	5.98	6.59
1 1/2"	1.5	2.159	2.377	6.51	7.18
1 9/16"	1.562	2.342	2.583	7.06	7.79
1 5/8"	1.625	2.533	2.793	7.64	8.43
1 11/16"	1.688	2.732	3.013	8.24	9.09
1 3/4"	1.75	2.938	3.240	8.86	9.77
1 13/16"	1.812	3.152	3.476	9.51	10.5
1 7/8"	1.875	3.373	3.719	10.2	11.2
1 15/16"	1.938	3.602	3.972	10.9	12.0
2"	2	3.838	4.231	11.6	12.8
2 1/8"	2.125	4.333	4.778	13.1	14.4
2 1/4"	2.25	4.858	5.356	14.6	16.2
2 3/8"	2.375	5.412	5.968	16.3	18.0
2 1/2"	2.5	5.997	6.612	18.1	19.9
2 5/8"	2.625	6.611	7.290	19.9	22.0
2 3/4"	2.75	7.256	8.001	21.9	24.1
2 7/8"	2.875	7.931	8.745	23.9	26.4
3"	3	8.636	9.522	26.0	28.7
3 1/4"	3.25	10.13	11.18	30.6	33.7
3 1/2"	3.5	11.75	12.97	35.4	39.1
3 3/4"	3.75	13.49	14.89	40.7	44.9
4"	4	15.35	16.94	46.3	51.1
4 1/4"	4.25	17.33	19.12	52.3	57.6
4 1/2"	4.5	19.43	21.44	58.6	64.6
4 3/4"	4.75	21.64	23.89	65.3	72.0
5"	5	23.98	26.47	72.3	79.8
5 1/2"	5.5	29.11	32.03	87.5	96.5
6"	6	34.54	38.12	104.	115.
7"	7	40.02	51.88	142.	156.

*Based on density of .02 lb./in.

Work it out!...

TO determine difference in cost between brass and aluminum, first figure total length of part including cut-off width. From weight table calculate pounds required to make 1,000 pieces from brass and from aluminum using this formula.

$$\frac{\text{Wt. per foot of stock X total length of Part X 1,000}}{12}$$

The total material cost for 1,000 parts of both brass and aluminum is then obtained by multiplying pounds required by price per pound* and subtracting value of scrap generated per 1,000 parts.

*ALUMINUM — use per pound price for 2,000 to 4,999 pounds.
BRASS — use per pound price for 10,000 pounds.

ALLOY WEIGHTS

Aluminum Alloy	Density lb./cu. in.	Wt. Conversion Factor
2011	.102	1.00
2017	.101	.99
2024	.100	.98
6061	.098	.96
Brass (free cutting)	.307	3.01

CONVERSION WORK SHEET

STOCK SIZE:_____ PART NO._____

LENGTH OF PART:_____ PART NAME:_____

CUTOFF WIDTH:_____

TOTAL LENGTH:_____

POUNDS OF_____ REQUIRED FOR 1,000 PIECES:

$$\left(\frac{\text{Wt. per foot of stock X total length of Part X 1,000}}{12}\right)$$

_____LBS. @ _____PER LB. = $_____

LESS_____% SCRAP = _____LBS. @ _____/LB. = $_____

COST OF MATERIAL FOR_____PARTS $_____

POUNDS OF ALUMINUM REQUIRED FOR 1,000 PIECES:

$$\left(\frac{\text{Wt. per foot of stock X total length of Part X 1,000}}{12}\right)$$

_____LBS. @ _____PER LB. = $_____

LESS_____% SCRAP = _____LBS. @ _____/LB. = $_____

COST OF MATERIAL FOR ALUMINUM PARTS . . $_____

IN_____ $_____

IN ALUMINUM $_____

SAVINGS PER 1,000 PCS. $_____ _____% SAVINGS

If your job is to design screw machine parts...work out your own examples... see how much you save by converting from brass to Kaiser Aluminum . . . gain advantages in high performance characteristics, less costly handling and shipping, stable material cost, easy machinability with . . .

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Actual Size

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Split-second accuracy and long wearing construction, never needs oiling. Front, rear or bottom set, with or without dustproof case. Simple mounting cuts production and assembly costs.

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Designed originally for World War II aircraft instrument and radio control mechanisms. Now being used for commercial applications demanding exceptional durability and dependability.

Synchron timing motors in all speeds available for prompt delivery

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HANSEN MFG. CO., INC.
OUR 50TH YEAR

Princeton 12, Indiana

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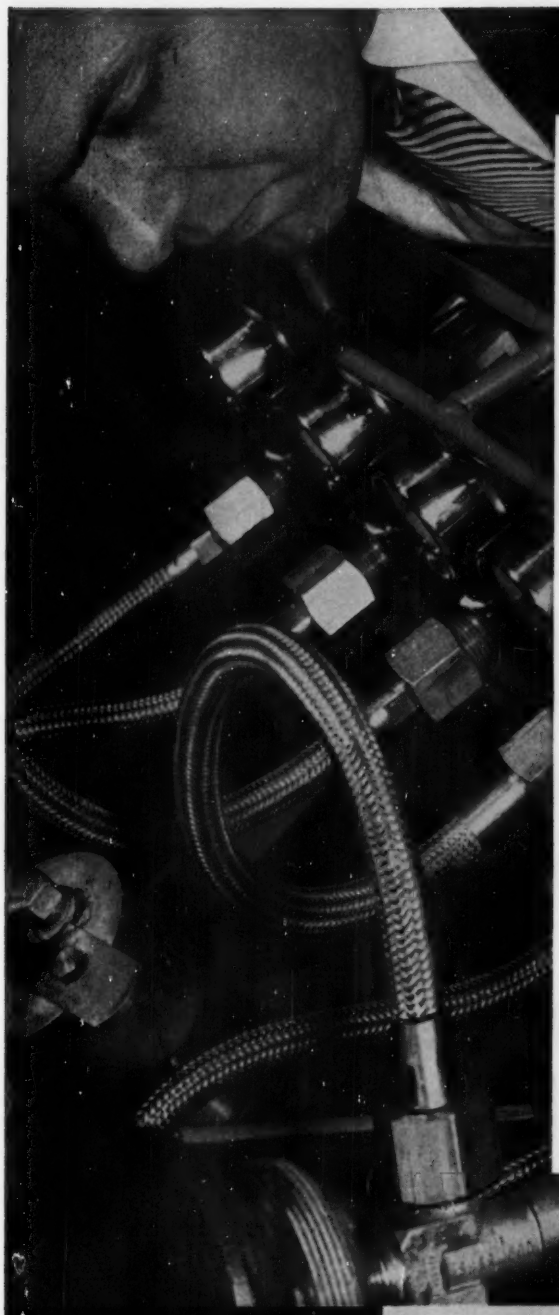

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Titeflex
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for conveying "Problem" Liquids and Gases!

Titeflex Hose solves scores of problems in conveying organic and volatile liquids as well as corrosive gases. Connects moving and/or misaligned machine parts, other terminal joints. Withstands high extremes in temperature, pressure. Absorbs vibration, shock, and flexing . . . with ease. Sizes 3/16" to 3" Other tough conveyance problems are solved with Titeflex flexible hose made of TEFLON* in sizes of 1/4" to 1 1/4".

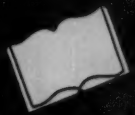
Titeflex
Quick-Seal Couplings

—the ideal "connecting mate" for Titeflex Hose or *any other kind of quality hose.* Connects or disconnects in ONE second and . . . the higher the pressure the tighter the seal!

Both these time-tested products are available for immediate shipment from distributors' stocks in most areas. Otherwise write, wire, or telephone direct.

*Du Pont trademark for its tetrafluoroethylene resin

CALL YOUR LOCAL DISTRIBUTOR



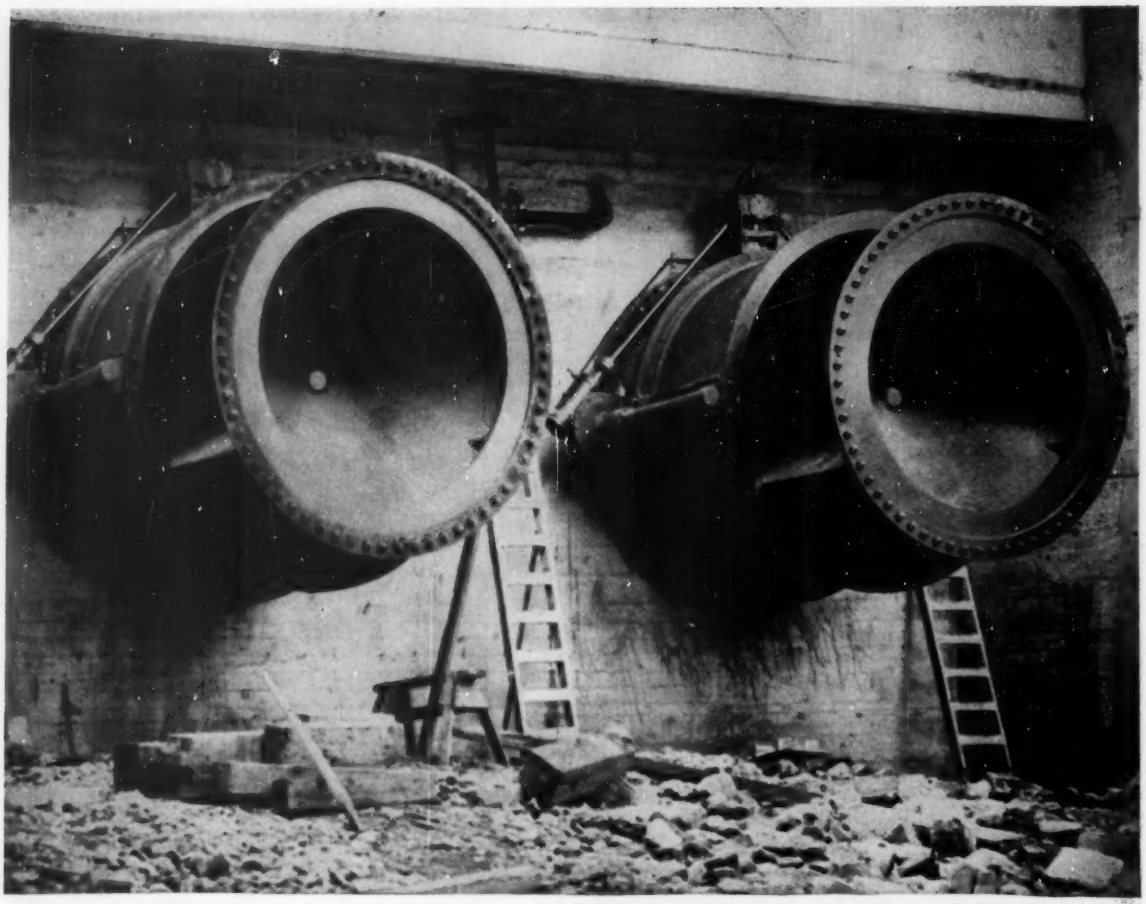
Consult the yellow pages of your telephone directory

Your one source for both Hose and Couplings

Titeflex

TITEFLEX, INC., 508 HENDEE STREET, SPRINGFIELD 4, MASS.

Circle 477 on page 19



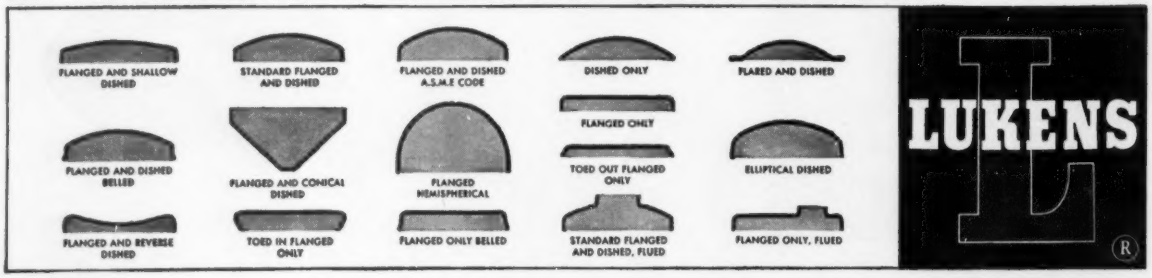
At British Columbia Power Commission's Ladore Dam, 96-inch Howell-Bunger valves dissipate energy from a 75-foot head of free-discharge water. Inverted cones on downstream ends are one-piece Lukens spun heads, a money-saving application.

Amazing what you can do...and save... designing with Lukens Heads

■ Ever think how Lukens standard head shapes might simplify the design of your machinery? Or permit entirely new design? Engineers at S. Morgan Smith, for example, build their huge Howell-Bunger valves using conical Lukens heads at the discharge end. Pre-formed heads reduce design complexity, eliminate costly fabrication steps.

Lukens heads may well improve *your* equipment design, reduce cost. The resources of Lukens' fifty years of leadership in producing heads for many applications are at your service. *Would you like technical details? Write for Catalog 658, "Pricing and Engineering Data", Lukens Steel Company, Coatesville, Pennsylvania.*

Lukens Offers the World's Broadest Line of Spun and Pressed Heads of Carbon, Alloy and Clad Steels

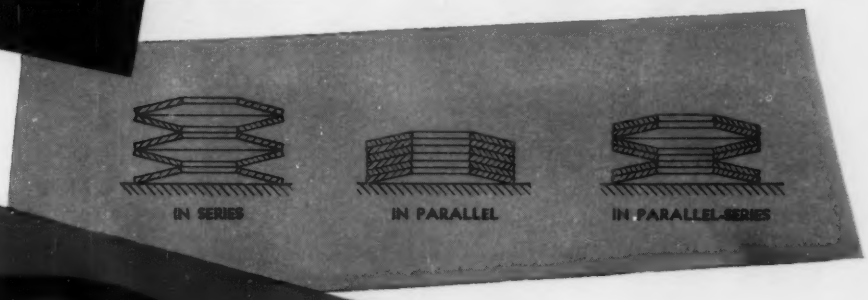


Circle 478 on page 19

Belleville Springs

Solve Spring Problems of HIGH LOADS in a Limited Space

This useful type of spring may be the answer to your need where space and load requirements are a problem. Made to any diameter or thickness—can be stacked in series, parallel, or parallel-series, or as an "Energy* Cartridge." The experience of our engineers is available in a pamphlet, "Belleville Washers." Write for your copy.



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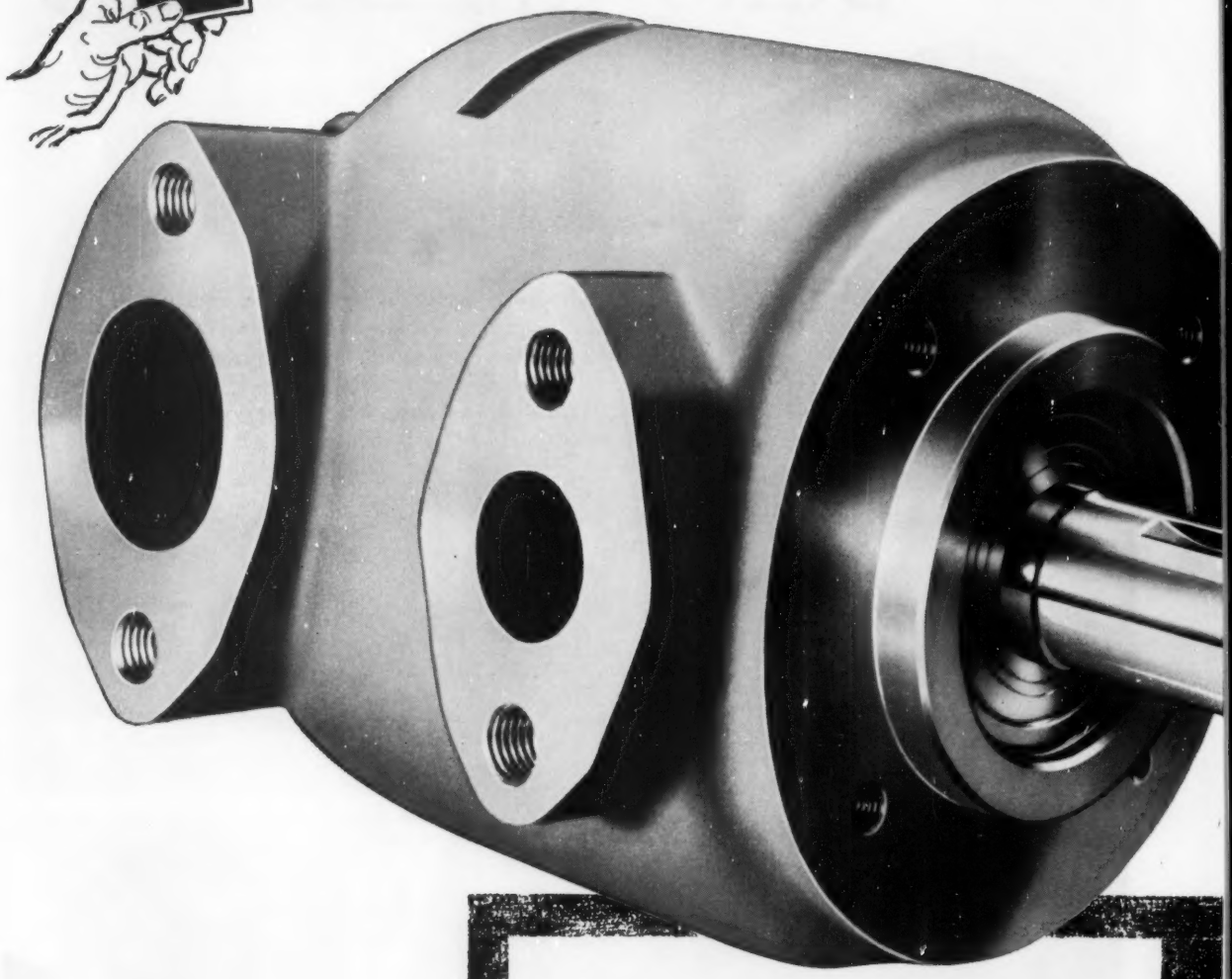
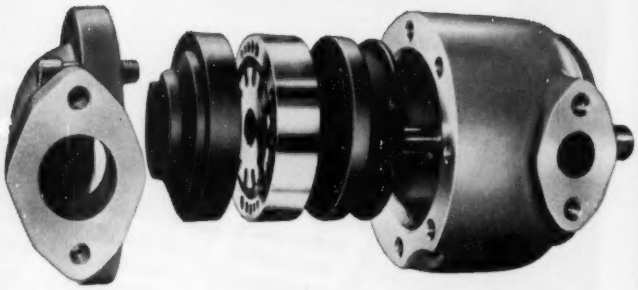
Circle 479 on page 19

NEW FROM DENISON



For mobile equipment
For special machinery
For automation



Denison's exclusive cartridge construction. *Side plates hydraulically loaded to maintain uniform pressure on rotor regardless of delivery pressure.*

Continuous 2000 psi service in a versatile vane-type hydraulic pump

FOR MOBILE EQUIPMENT, less weight, increased payload

FOR SPECIAL MACHINERY, more power in less space

FOR AUTOMATION, heavy-duty design for low maintenance

● Here are the important features you can engineer into your designs with Denison's new "T" Series balanced vane hydraulic pump.

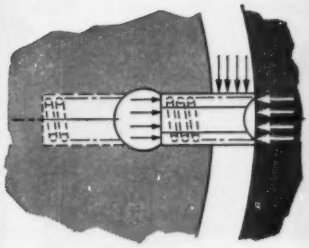
Long, efficient life because Denison's fully-balanced vanes and rotors reduce wear on cam rings and thrust plates to give long pump life with minimum maintenance.

Packs More Power in Less Space. Internal friction is lower, volumetric efficiency is higher. Actually packs 50 h. p. in less space than a conventional 3 h. p. electric motor where space and weight are a premium.

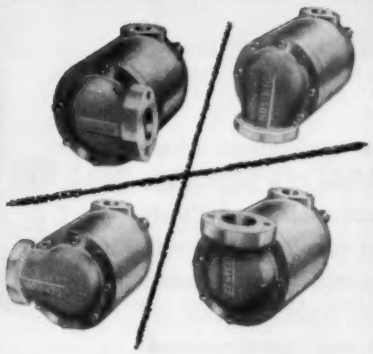
Cold-Weather Starting, under severe weather conditions, to maintain construction schedules.

Fast, Easy On-the-Job Service because the complete pumping cartridge can be removed and replaced as a unit without special tools or skills.

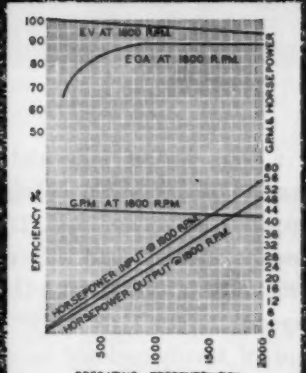
Write for complete engineering specifications in Bulletin 200. Denison Engineering Division, American Brake Shoe Co., 1240 Dublin Road, Columbus 16, Ohio.



***Hydraulically balanced vane construction** cuts excessive wear on vane and cam ring . . . for longer life, higher volumetric efficiency.*



***Universal Mountings** . . . may be mounted in any of four different positions—face, flange or bracket mounted. Operates clockwise or counter-clockwise.*



Performance curve of "T Series" vane-type pump illustrates high volumetric efficiency.

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

DENISON *HydrOILics*

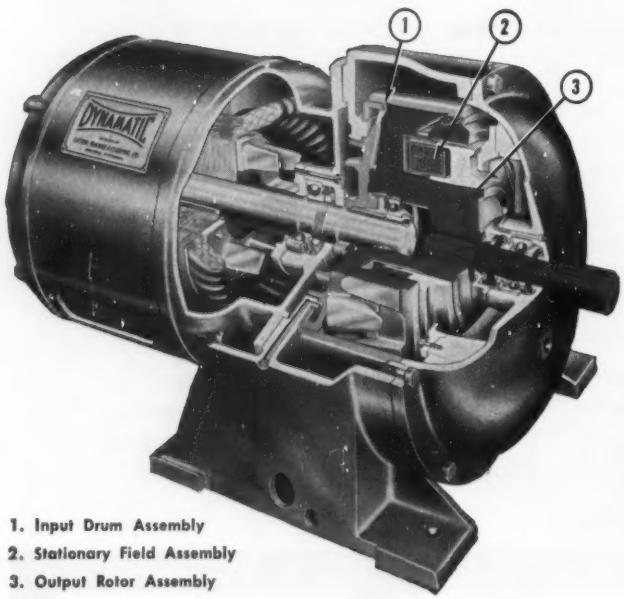
Circle 480 on page 19

EATON

DYNAMATIC®

DYNASPEDE® ADJUSTABLE SPEED DRIVES

Provide these important Advantages



1. Input Drum Assembly
2. Stationary Field Assembly
3. Output Rotor Assembly

1. Adjustable speed from AC power source
2. Accurate speed control
3. Wide speed range
4. Rapid response
5. Low power losses
6. No commutators, rings, brushes, or rotating coils
7. Simple construction
8. Remote control
9. Quiet, efficient operation
10. Low maintenance cost

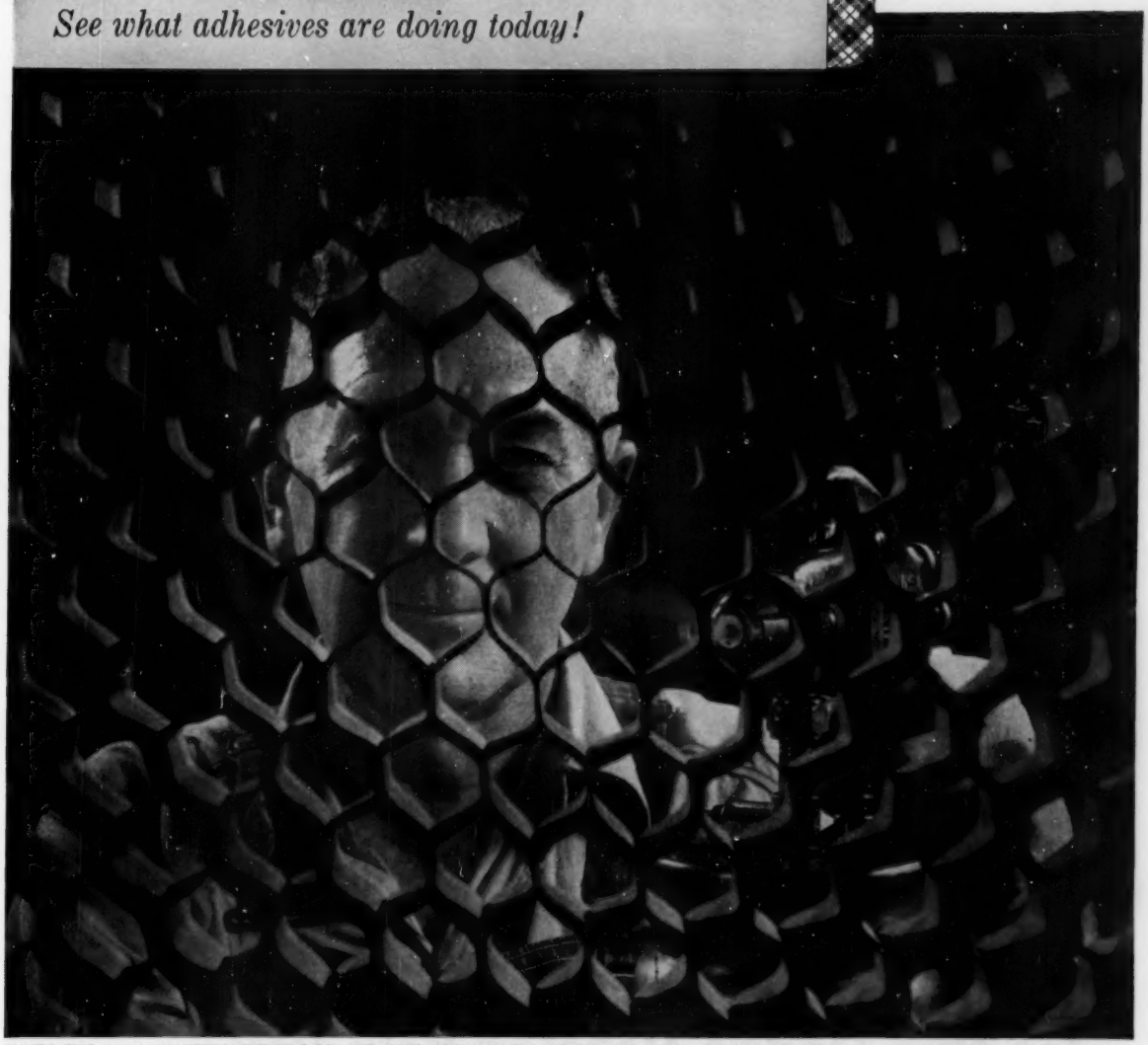
For a long list of industrial drive applications where stepless adjustable speed is required, the new Dynamatic Dynaspede® Drives are ideal. The liquid-cooled, completely enclosed, stationary field eddy-current couplings are available mounted integrally with D-flange squirrel cage motors in capacities from 3 to 75 HP. Motor types available are drip-proof, totally enclosed fan-cooled, and explosion-proof.

Separately mounted couplings in capacities from 3 to 2500 HP, and larger, are also available. Dynamatic electronic or magnetic amplifier controls, in combination with these drives, provide wide latitude in operating functions.

Send for Illustrated Literature Describing These New Stationary Field Drives and Couplings

EATON DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

See what adhesives are doing today!



WHEN THIS MAN SQUEEZES THE TRIGGER, HE CUTS PRODUCTION COSTS. HIS SPRAY GUN IS LOADED WITH A MODERN ADHESIVE BY 3M.

Shooting holes in production costs

Every day this worker shoots holes in his company's manufacturing costs. The 3M adhesive in his spray gun creates a structural sandwich that's inexpensive, featherweight and strong. *Naturally this adhesive is a favorite with the comptroller.*

3M adhesives like EC-1357 and EC-1177 bond a honeycomb paper core between thin metal skins. They produce rigid, more durable units from such light materials because they're tougher, more flexible. Many industries benefit: building, furniture, aircraft, railroad equipment and others.

These 3M adhesives are specially designed for this sandwich construction, thoroughly tested. They apply fast and easily, like the hundreds of varied 3M adhesives for other uses.

SEE WHAT ADHESIVES CAN DO FOR YOU!

Consult 3M research. Contact your 3M Field Engineer. Or for information and free literature write on your company letterhead to: 3M, Dept. 103, 417 Piquette Avenue, Detroit 2, Michigan.

PRODUCT OF 3M RESEARCH

3M ADHESIVES

ADHESIVES AND COATINGS DIVISION, **MINNESOTA MINING AND MANUFACTURING COMPANY**

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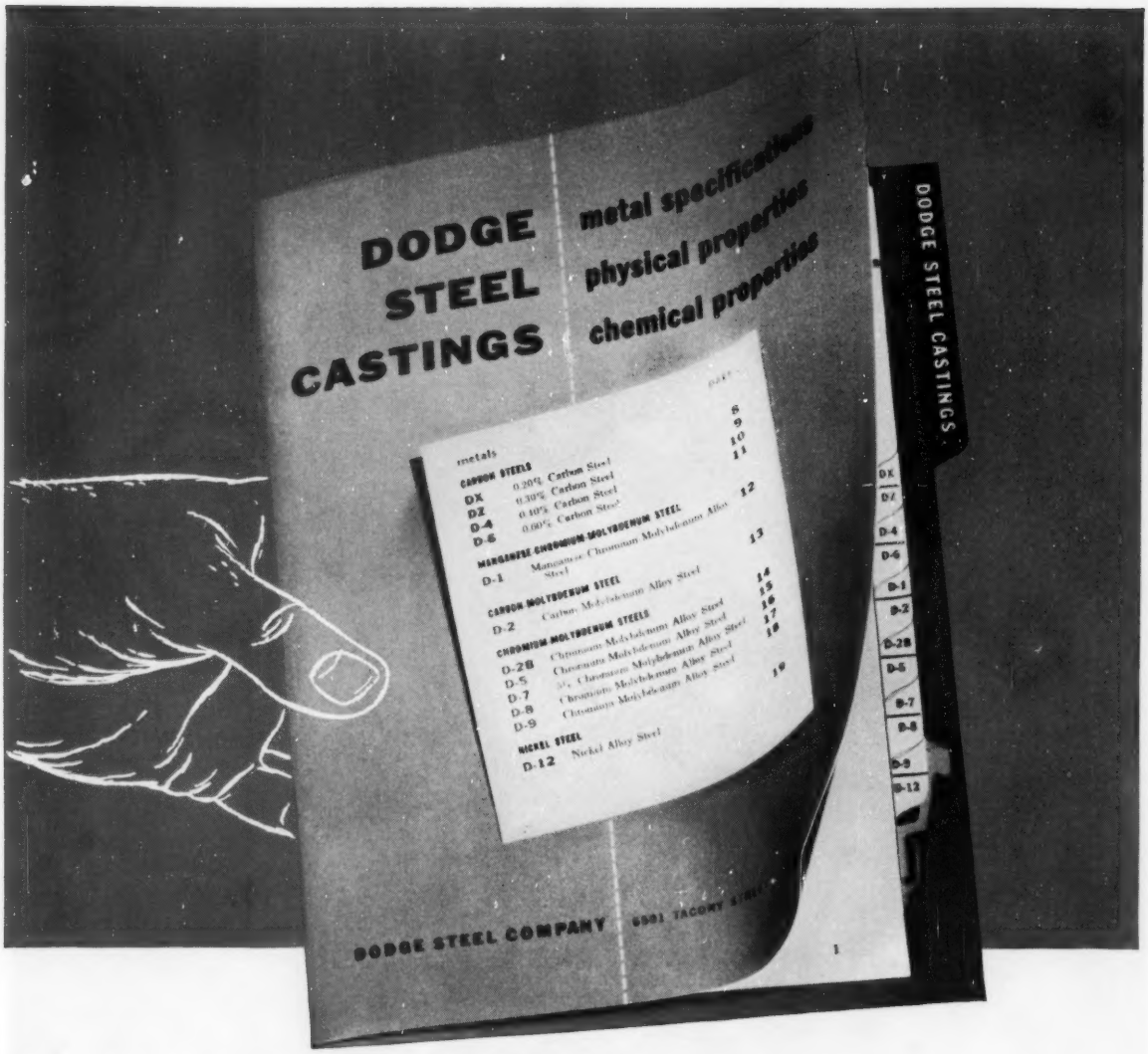
MAKERS OF "SCOTCH" BRAND PRESSURE-SENSITIVE TAPES • "SCOTCH" BRAND SOUND-RECORDING TAPE • "SCOTCHLITE" BRAND REFLECTIVE SHEETINGS • "3M" ABRASIVE PAPER AND CLOTH • "3M" ADHESIVES AND COATINGS • "3M" ROOFING GRANULES • "3M" CHEMICALS

Circle 482 on page 19



let this Dodge Catalog help you build a Better Product . . .

If you buy, use, or design with steel castings, you'll want this new 20-page Dodge catalog. Here, in handy, compact form you'll find complete data on metal specifications, chemical and physical properties of all Dodge metals . . . plus tips on how to buy for value and profit, selection data and a hundred other important engineering facts you'll refer to repeatedly. Like a free copy? Use the handy card that comes with this publication or write us direct. Why not do it *today?*

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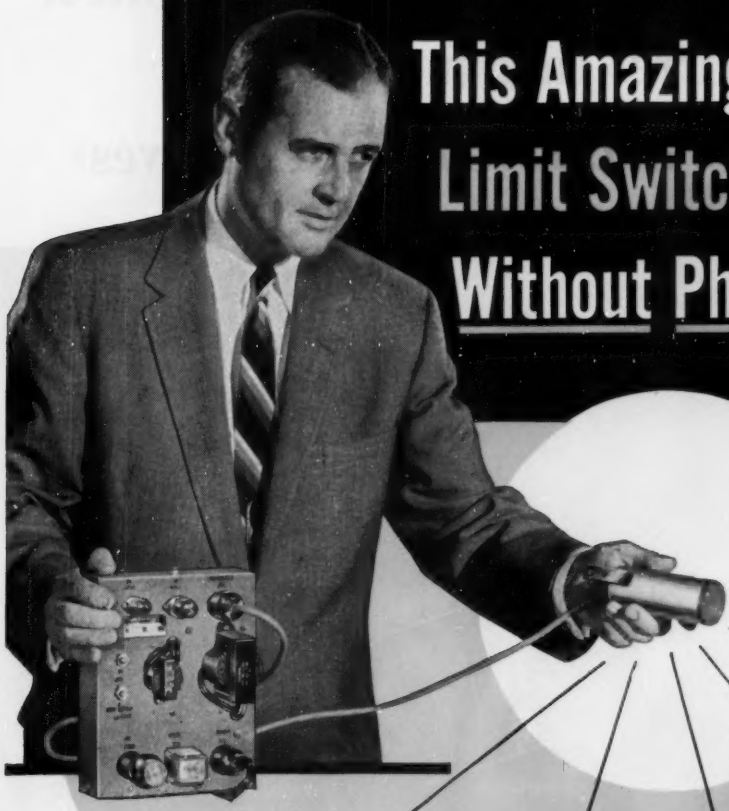
6501 Tacony Street • Philadelphia 35, Pa.

THE MOST IMPORTANT ALLOY IN A STEEL CASTING IS QUALITY

Circle 483 on page 19

This Amazing New Limit Switch Operates Without Physical Contact!



Transducer (sensing head) is actuated by presence of magnetic materials over a wide range of sizes, shapes, weights, roughness, speeds

No moving parts. No metal-to-metal contact required for operation

Sensitivity up to 1 inch

Can be mounted in any position. Not affected by vibration

Small size (1⅞" x 6") Fits into tight spots

Non-magnetic material between the part and transducer does not affect operation

Here's an entirely new concept in industrial limit switches! We've named it the **PROXIMITY LIMIT SWITCH** because it is actuated by the nearness of ferrous parts or materials. Since its operation requires no physical contact, it has unlimited applications in places where the use of conventional limit switches is either impractical or impossible! Its range of application is broadened, too, because the transducer (sensing head) is not affected by vibration or by the presence of non-magnetic material.

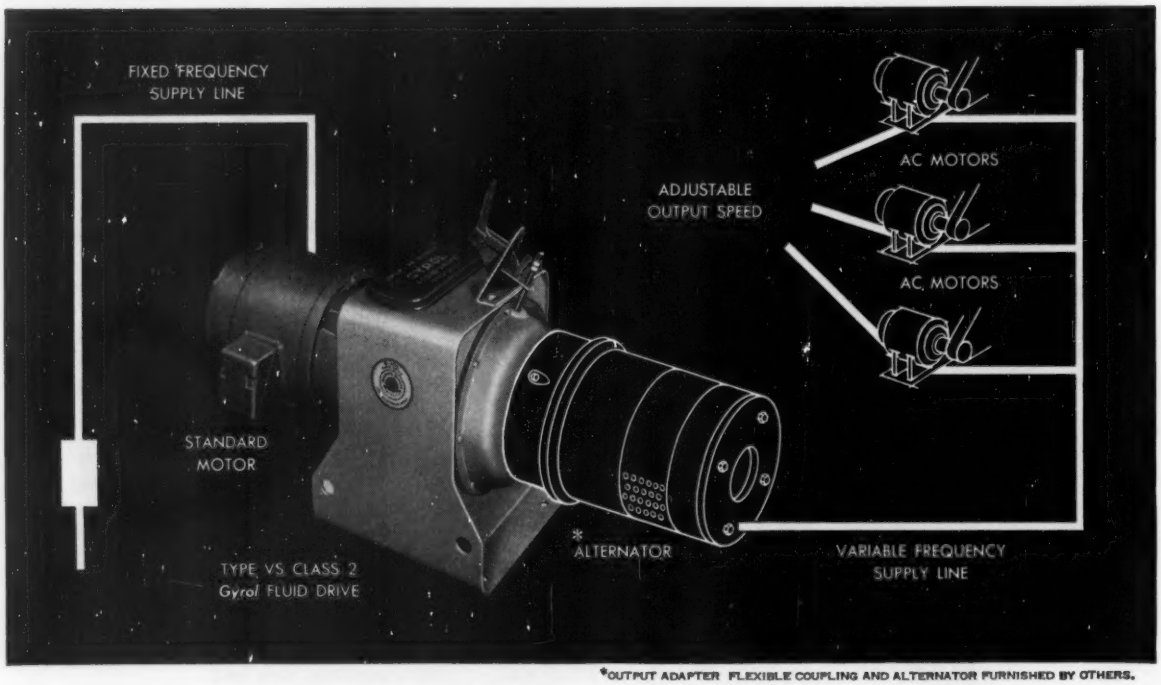
In paint spray systems, on production line presses, multiple process machines, heavy automation equipment—there are literally scores of places where this amazing new PROXIMITY SWITCH will do the job better!

ASK YOUR SQUARE D FIELD ENGINEER FOR A DEMONSTRATION. OR WRITE FOR PROXIMITY LIMIT SWITCH BULLETIN. ADDRESS SQUARE D COMPANY, 4041 NORTH RICHARDS STREET, MILWAUKEE 12, WISCONSIN

NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE!

SQUARE D COMPANY

Now—get matched, adjustable-speed control of AC squirrel-cage motors with American Blower *GYROL*® Fluid Drives



*OUTPUT ADAPTER FLEXIBLE COUPLING AND ALTERNATOR FURNISHED BY OTHERS.

A Gýrol Fluid Drive coupled to a standard alternator can vary the output speed of two or more AC motors. For example, a standard induction motor can operate at rated speed at 60 cycles, or half rated speed at 30 cycles, since speed for a given motor is proportional to frequency.

Here's a simple system for varying the output of two or more standard, constant-speed AC induction motors – simultaneously – to equalize load distribution, prevent costly machinery breakdowns.

An alternator, driven through an adjustable-speed Gýrol Fluid Drive, makes variable frequency available from a fixed-frequency power source. Since AC motors operate at speeds proportional to the frequency of applied power, motor speed is controlled by merely regulating the Gýrol Fluid Drive.

What's more, motors of different speeds or types can be used in the same system, and will change speeds proportionately; single-motor systems can also be set up. Control can be manual, semi-automatic, or automatic, and is adaptable to infrequent or frequent repeat cycling.

If you're looking for more dependable, lower cost adjustable-speed control of driven machinery, with fewer breakdowns, lower maintenance, why not look into a Gýrol Fluid Drive coupled to a standard alternator. Call our nearest branch office for full details. American Blower Division of American-Standard, Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ont.

AMERICAN BLOWER

Division of AMERICAN-Standard

Circle 485 on page 19

still the winner

... and in high speed steels, nothing beats REX

The winner and still champion after fifty years is Crucible's REX high speed steel. *And now it's better than ever!* Recent improvements in manufacturing processes have given even higher quality and greater uniformity to every one of its properties.

Why not shop test the new REX yourself? Test it for size, structure, response to heat treatment, fine tool performance. Give it any test you wish. You'll see why it is today, as it has always been — *the standard by which all other high speed steels are compared.*

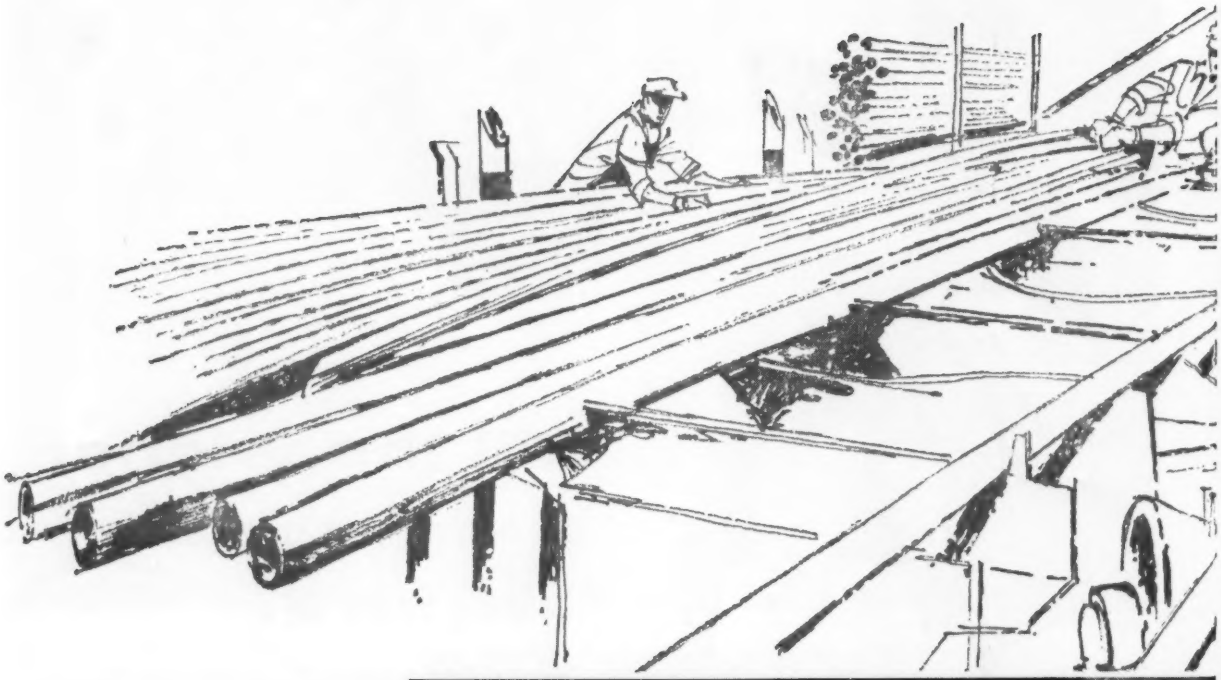
Ask for REX by name at your local Crucible warehouse. Or order it directly for prompt mill delivery. And for information on REX, and the other Crucible special purpose steels, send for the *Crucible Publication Catalog. Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

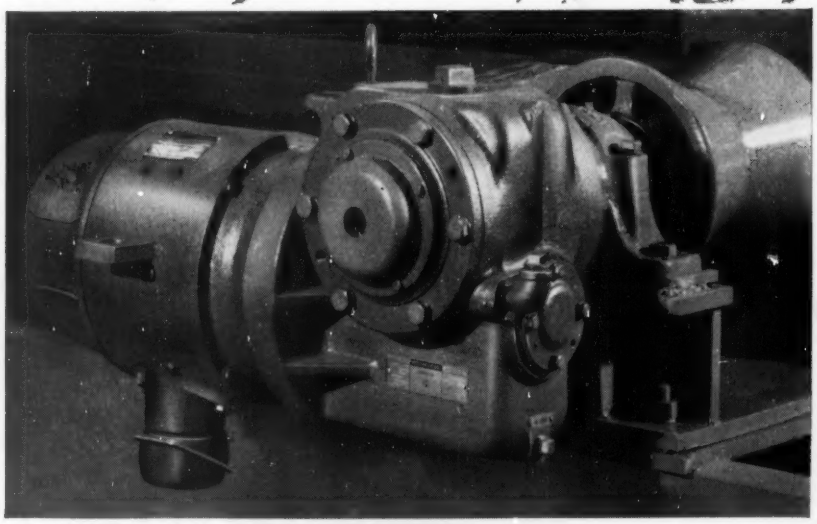
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

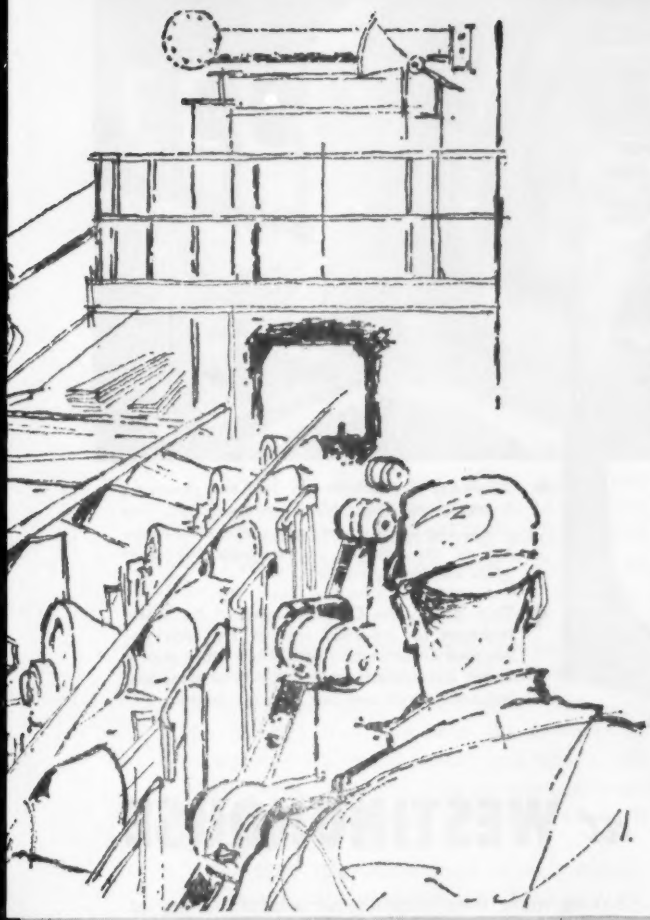
Circle 486 on page 19

Seamless tube delivery gets **Triple protection in**





Westinghouse floating gearmotors

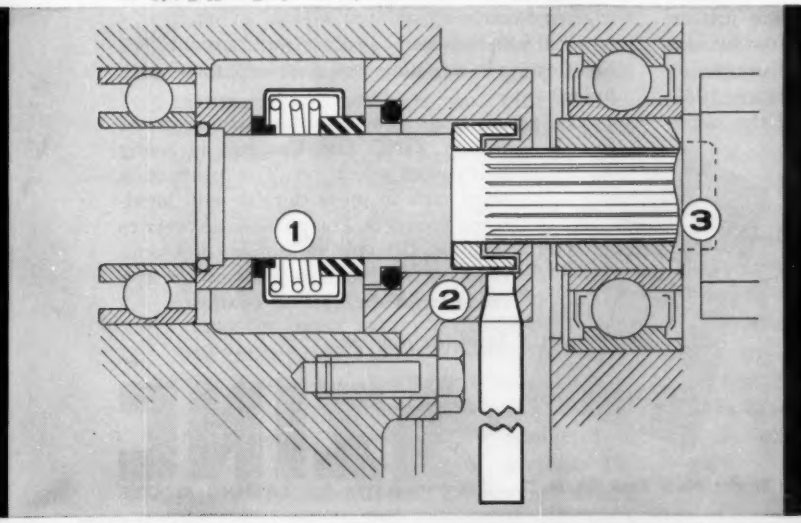


Westinghouse floating shaft gearmotors have undergone the critical tests of 24-hour-a-day, run-out table operations. Typical results come from a seamless tube drawing, tempering and annealing operation. Here, Westinghouse units bring three-way protection against the always-present problems of oil leakage and motor changes.

Two separate seal systems guard against oil leaking from the gear unit into the motor. An indicating feature warns of seal wear, before failure, in time for preventive maintenance.

Westinghouse splined shaft coupling permits easy separation of motor and gear assembly in seconds. Valuable inspection time is saved and motor changes can be made on the job, reducing down time.

Shock-absorbing spring mounting and rugged construction make Westinghouse floating-shaft gearmotors extremely tough . . . but why not see for yourself in Booklet B-6370. Call your local Westinghouse sales engineer for a copy, or write Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa. J-07354



1. A combination labyrinth-packing and face-type seal on the pinion shaft prevents oil leakage from the gear housing into the motor.

2. For added protection an umbrella seal and drain catches any leakage through a worn shaft seal. Visual indication of seal wear is given by the drain.

3. The simple spline connection between motor and gear shafts permits fast demounting of the motor without disturbing gears or bearings.

YOU CAN BE SURE...IF IT'S Westinghouse

PRODUCTION SHORT CUTS WITH

ZINC

DIE CASTINGS

NUMBER 5 OF A SERIES

▲ Assembly is a simple job with two mounting brackets and dust shield pre-assembled. The ZINC Die Casting becomes a structural member of the cabinet and supports the front glass and tuning controls.

◀ This ZINC Die Casting, designed by Westinghouse for its 1957 line of TV receivers, requires no secondary operations other than a baked electrostatic spray finish. The name and indicator arrow are cast into the frame.

Framing the picture at WESTINGHOUSE

At WESTINGHOUSE, TV designers recognize that *appearance* and *production cost* are just as important as maximum performance to the success of a new line of receivers. To get the utmost in eye-appeal and production economy in the 1957 models, WESTINGHOUSE combined the outer screen frame and the cabinet front in a beautifully designed, one-piece ZINC Die Casting.

How else could the front panel and screen mask be produced complete with mounting studs accurately cast for quick assembly?

How else could the necessary control openings and parts recesses be provided without expensive machining?

How else could you secure a part having more than adequate structural rigidity at a great saving in cost?

What other metal or process could excel ZINC Die Casting in attaining such a clean, satin-smooth finish?

These basic qualities account for the widespread use of ZINC Die Castings in many fields—uses which result in production short cuts to more durable and handsome products. For possible answers to *your* manufacturing design problems, send for our brochure and contact any commercial die casting company.

◀ **Send for your copy.**

The New Jersey Zinc Company, 160 Front Street, New York 38, N. Y.

ZINC
FOR DIE CASTING ALLOYS

The research was done and the Zamak die casting alloys were developed with

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

MACHINE DESIGN
March 21, 1957

The Salary Index

SEVERAL years ago, when status and salary of engineers began to be so much discussed, an engineering executive told us, "The question is academic. The law of supply and demand will make well-paid professionals of all of us."

This optimistic but faintly cynical prediction of the effects of the demand for engineers has certainly come true in part. For the record, what has been the increase in salary levels in recent times? And what about the common complaint that experienced engineers have not gained proportionally as much as engineering beginners?

The 1956 Engineer's Joint Council survey, reported in MACHINE DESIGN, February 21, Page 14, shows that engineers' salaries rose approximately 23 per cent between 1953 and 1956. The frequent criticism that experienced engineers have not kept pace with starting salaries of new graduates is seemingly given the lie by this report. Annual starting salaries for engineers increased about $1000 from 1953 to 1956 and the salaries of 15 to 20-year men increased about $2000. Increases were about 15 per cent for beginners and about 25 to 30 per cent for 15 to 20-year men.

Another recent survey contradicts the popular "salary-compression" theory. The *Northwest Professional Engineer,* a publication of the Seattle Professional Employee's Association, reported a salary study conducted in co-operation with the Boeing Airplane Co. This study showed that the median salary for nonsupervisory engineers at Boeing—those with 15 to 20 years' experience—fluctuated in a narrow band of 1.40 to 1.55 times the starting salary, from 1947 through 1956.

Neither report supports the notion that salaries have become compressed between the starting engineer and those on the job 15 to 20 years.

In fact, a theory in direct contrast to salary-compression can be propounded from the foregoing observations: The price paid for beginning engineers is a reliable index to salary levels for experienced engineers. The new engineer is a commodity in a free market. As the price bid for him rises, the fortunes of his seniors improve—perhaps not in a day but certainly soon enough to encourage patience.

Most companies evidently have all along been operating in the spirit of this idea. The same association cited above, incidentally, believes in the principle firmly enough to propose it as a formal basis for annual salary adjustment of engineers. (See Page 15, this issue.)

Exception may be voiced from two quarters: from those men who encounter a local lag in response to the general trend, and from those who fail to realize that their salaries have leveled off because their own contributions to success of the business have reached a plateau. Patience or action will reward the former. Self-appraisal may lead the latter to find how to get off dead center—or how to be happy there.

Statistics define the population, not the man.

Ben Hummel

ASSOCIATE MANAGING EDITOR

Both simplified and conventional drafting systems have advantages and disadvantages, adherents and critics. But, the best system for any engineering department is that one which fulfills all requirements at minimum cost. Points discussed here can lead to . . .

EFFICIENT DRAFTING

STORMS of contention have centered on drafting practice. Many engineering departments have abandoned the time-honored precepts of conventional drafting and adopted systems that they considered faster, better, or more economical. Curiously enough, this evolution has produced two widely divergent forms: simplification of graphical conventions, and elaboration of information content—especially in regard to dimensional information.

To further confuse the issue, there is a marked difference between the academic treatment of the subject, and drawing practice which best serves the needs of industry. Reasons for this separation of theory and practice are not hard to find. Drafting materials, instruments, and reproducing techniques have changed; facilities and working conditions for draftsmen have changed; so has the organization of many drafting operations. But, the most important reason is because of what industry now expects of drawings. More and more, drawings are expected to state exactly what is wanted, leaving little to the discretion of the shop. Moreover, where work is subcontracted, drawings must be regarded as legal documents, complete and unambiguous.

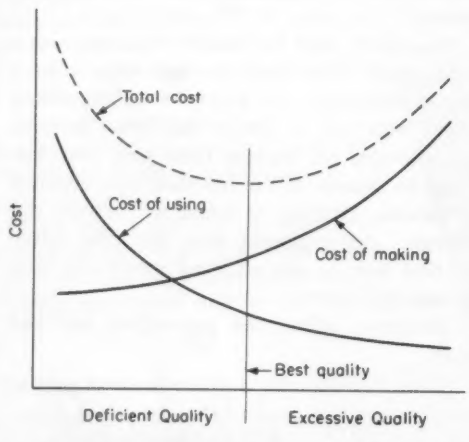


Fig. 1—Total cost of a drawing is least when rising cost for improved quality equals decreasing cost of use.

Industry's Need for Drawings: It is unthinkable to suppose that industry could function effectively without drawings. Drawings record and convey information that can hardly be expressed by words alone.

Drawings perform many vital functions. More likely than not drawings are the chief tool used when an idea for a product, plant or piece of equipment is sold to management. Although a design takes form as thoughts in a designer's mind, these thoughts are crystalized only when they have been embodied in sketches and accurately scaled layouts. Drawings are instructions for patternmakers, machinists, welders and assemblers; drawings record essential information for the user of a product; drawings illustrate reports, patents and catalogs.

Economics and Drawings: Every drawing should justify the cost of its preparation and use. In addition, the cost of this preparation and use should be maintained at a minimum. Detail and assembly drawings are especially important in this respect, as most drafting operations are concerned with making details and assemblies. There are no simple rules that show how drawings should be made just-good-enough. What is good enough for one case may not be for another. A representation of the best drawing is shown in Fig. 1. This ideal is hardly attainable in practice. The evaluation of drawing quality is not exact enough to construct accurate cost-quality relationships. Yet, in spite of the limitations of graphical representation, this concept is basic to the philosophy of sensible drafting practice.

Cost of making drawings includes the salary of the drafting force and the usual expenses of equipping and maintaining drafting facilities and services. Cost of using drawings includes the expense of reproducing and reading the drawings. Most important of all, the cost of using a drawing is

PRACTICE

By Earlwood T. Fortini, *Mechanical Engineer*
Datamatic Corp., Newton Highlands, Mass.

reflected in how well the drawing specifies how a part should be made, or how a group of parts are to be put together.

In the cost-quality curves shown in Fig. 1, it is taken for granted that as the cost of making a drawing goes up, the cost of using it goes down. Whether or not this assumption is borne out in practice depends on efficiency of the practices that are followed to obtain the most economical quality.

Quality: The quality of a drawing is a measure of its readability, completeness and compactness. A drawing is readable if it is easily understood—information orderly arranged, lines clear and sharp, notes neat and legible. A drawing is complete when every significant detail is specified and when there is no likelihood of misreading or omitting an important requirement. Ordinarily the more compact a drawing, the better—unless it is so small that information is crowded and hard to read. Size of a drawing reflects in reproduction costs. Large drawings are awkward to handle, especially in the shop, and take a lot of filing space.

Some of the factors that have a bearing on drawing quality are related to what a drawing represents; other factors are related to the operation of the drafting department. These factors determine how many times a drawing must be reproduced, how many hours will be spent in reading it and by whom, how exact the drawing must be, what material the master is drawn on, and similar considerations.

From a study of all of the factors involved, the most appropriate level of drafting practice can be decided. For each level of practice, there are preferred methods and techniques concerning the composition of drawings and the administration of a drafting operation.

COMPOSITION OF DRAWINGS

All drawings are not alike, although a comparison of any two drawings will reveal many similarities. These similarities stem from the common attempt to satisfy certain general needs. Drawings must usually be reproducible, bear adequate identification, include necessary administrative data, and —most important of all—contain technical information. How these needs are satisfied can be appreciated by a study of the basic ingredients that comprise a drawing. In the case of detail drawings, these ingredients are: format, picture, dimensions and notes.

Format: Even a rough sketch on the back of an envelope can fit the best-drawing definition of Fig. 1—but usually doesn't. Much more is ordinarily required of a drawing than can be satisfied by such a primitive format. Common practice is for all but the smallest drafting operations to make drawings on printed, reproducible forms. This is sound, economically justified practice—if it is not overdone. It is overdone when a form is cluttered with unessentials. Such unessentials can make a drawing hard to read, waste valuable space, crowd important material, or require a larger sheet. What is really essential and what is not, depends on what the drawing is for.

Two formats are shown in Fig. 2. Many of the features found on Fig. 2*b* have been purposely omitted from Fig. 2*a*. Among these omissions are: revision block, place for draftsman's signature, standard tolerance table, and note indicating scale of drawing. Arguments may be advanced defending inclusion of the items omitted from Fig. 2*b*. But, just the opposite conclusion may be reached.

The particular way in which a drawing is employed will determine whether it is economically sensible to include or exclude an item from a drawing. The point to remember is this: just because an item is customarily found on a drawing is not good enough reason for its being there.

The Picture: Some simple parts can be described by words only. For example, a washer can be specified by inside and outside diameters, thickness, and material. But for a word description, *washer* must represent a known and very simple geometrical form. The difficulty—perhaps impossibility—of describing most parts by words is quite obvious.

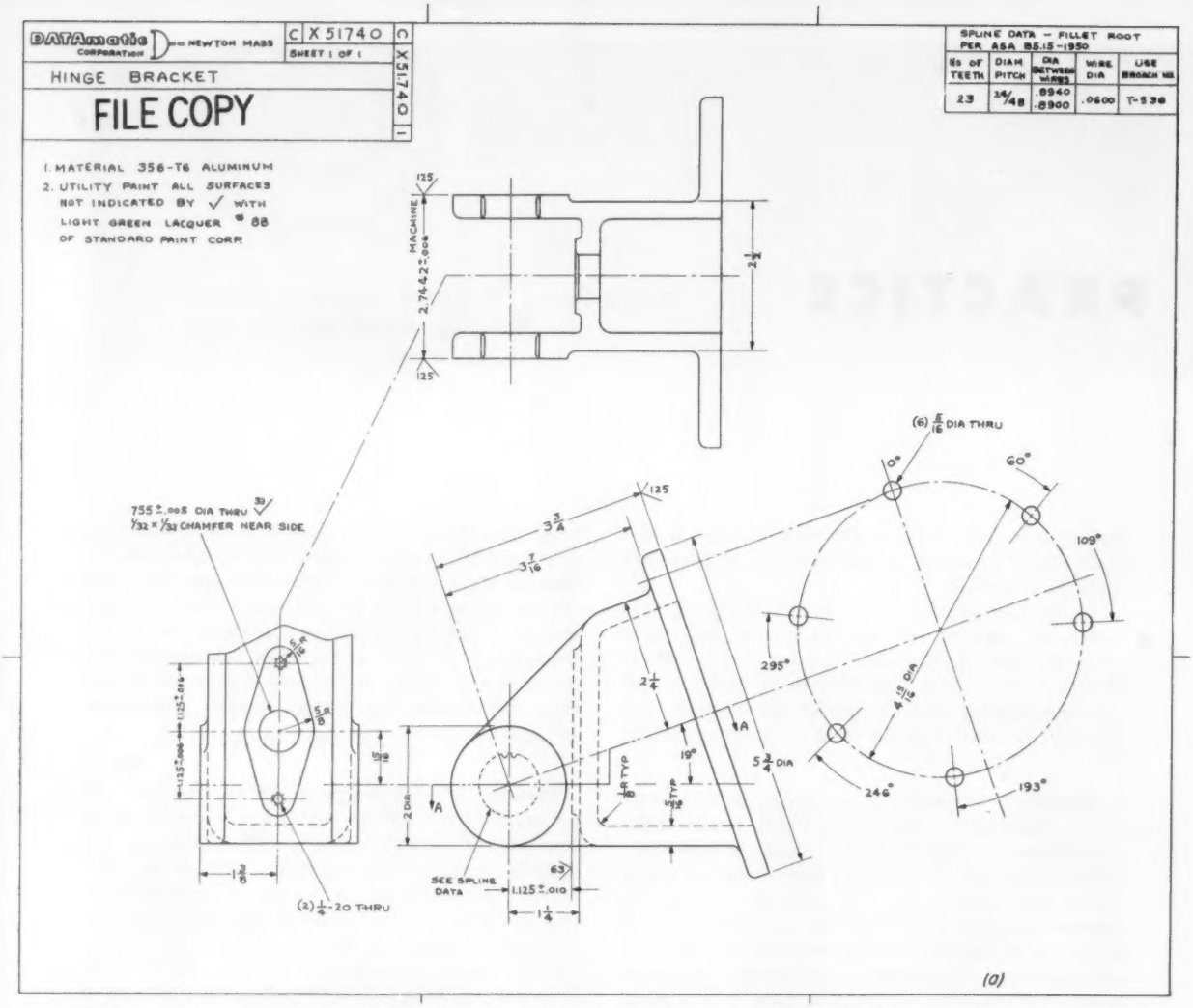
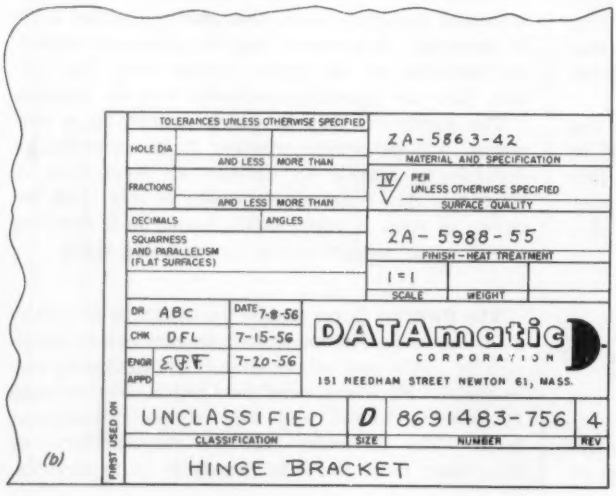
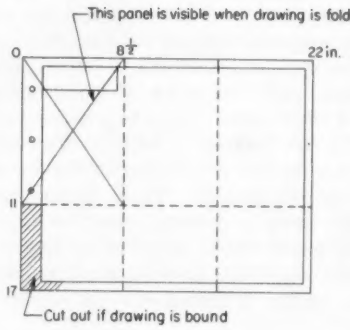
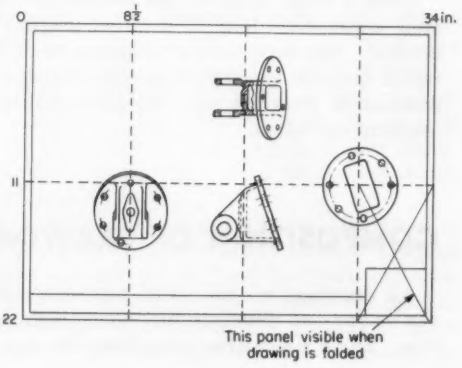


Fig. 2—Development of new drafting standards within one firm to suit their needs. At *a* is the adopted standard which grew from the conventional format in *b*. The new standard format and drawing system contains the same information as the old, but is easier, faster, and less expensive to produce. The format was designed for simplicity and to facilitate filing and binding. The space-saving feature of the new system, as compared with the old, is shown.







Perspective drawings make natural, easy-to-read pictures. Perspectives, however, have limited use for drawings of mechanical parts because they require a great deal of time and skill. Furthermore, perspectives are not easily dimensioned.

Simplified forms of three dimensional pictures are somewhat easier to draw than perspectives but have the same basic restrictions. Most of these drawings are made according to the system called third-angle projection. This system is based on a few simple rules which are usually given at the beginning of drawing courses. Later in these courses the exceptions to the rules are introduced, and that's where problems begin.

An example of why it is sometimes necessary to make exceptions to the rules is illustrated by Fig. 3. According to a rule of third-angle projection, lines are imaged on a plane by projecting tangents to surfaces and edges of a solid. For the part shown in Fig. 3*a*, this rule can be literally applied. It cannot be, however, in Fig. 3*b*. Here a more practical alternate is to project only certain imaginary intersections.

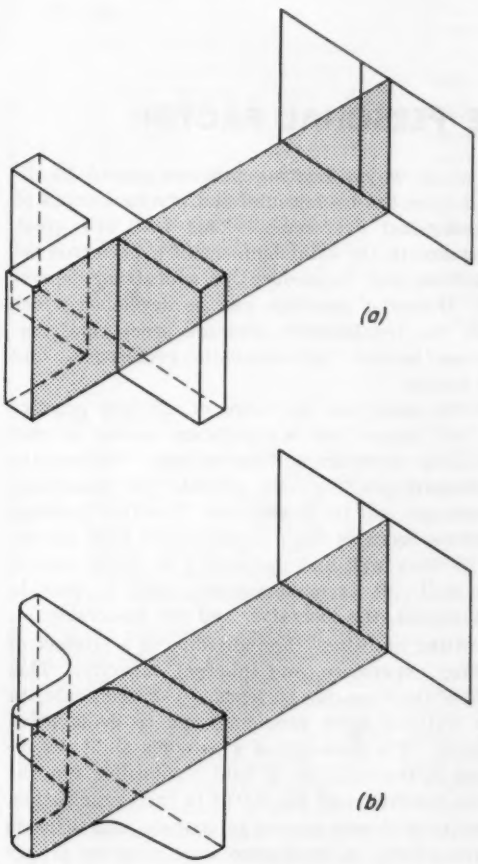


Fig. 3—Projections of both *a* and *b* look alike even though the parts depicted are different in shape. Projection from actual intersections was used for *a;* imaginary intersections were used for *b*.

It should be apparent that third-angle projection cannot be treated as if it were merely a branch of applied geometry. Thus, in order to make the system more usable, many conventions have been devised to avoid some of the inherent difficulties. These conventions have two purposes: to simplify pictorial representation, and to replace pictorial with symbolic representation.

Just by the skillful use of well-known conventions, great savings can be realized in the cost of making and using drawings. It should not be presumed that no improvement is needed or possible. In time, many more cost-cutting practices will find general acceptance. Unfortunately many companies are not in a position to pioneer new drafting practices. For these companies, economical drafting practice must be realized by making the best use of current, nationally recognized conventions.

Dimensions: Dimensioning drawings can be a difficult, exacting task. Careless, inexpert dimensioning can result in unduly close tolerances, inappropriate fits or faulty performance.

The theory of dimensioning engineering drawings concerns the purpose of dimensions, how they are derived, and correctly showing them on the appropriate drawings. There are several kinds of dimensions. Those that describe geometrical features such as cylindrical, rectangular or conical forms, or irregular contours are called *feature dimensions.* Dimensions locating geometrical features are called *positional dimensions.*

Some dimensions are important for functional reasons, other are not. Relationships between functional dimensions control conditions that affect assembly or operation of a device. Dimensions that do not have an effect on assembly or function, other than the specification of size and form satisfactory for meeting strength and other requirements, are called *constructional dimensions.*

What has been said here about dimensions hardly does more than introduce a few terms. The purpose of this introduction is to show that dimensioning is a subject founded on definite, consistent ideas. Only by following systematic methods and practices is it possible to derive, record and verify dimensions efficiently and economically.

Notes: On some drawings, only the briefest notes are necessary. This is true when workmen have an understanding as to what grade of workmanship is appropriate. In many cases, however, it is not good business to merely expect "good workmanship." Notes like the following may be necessary:

1. Remove all burrs and sharp edges.
2. Surface *"A"* to be flat within 0.001-in.
3. Diameter *"B"* to be concentric with diameters *"C"* and *"D"* within 0.003-in. T.I.R.
4. Edge *"E"* to be free of any dent or nick greater

than 0.005-in. deep or 0.020 long.
5. Clean and package per SPEC. S-174-A-05 prior to shipment.

There is a practical limit as to how detailed or copious notes should be. General standards of workmanship may be spelled out in a specification which is referred to on all drawings. Notes and specifications must be used carefully, for they tend to develop into a complicated cross-referenced maze which takes hours to explore, sometimes leading to doubtful or erroneous interpretations.

The Set of Drawings: The various parts of a drawing; format, picture, dimensions and notes; have greatest significance when considered with respect to the whole drawing. In a like sense, a drawing has greatest significance when considered with respect to the set of drawings of which it is a part. It is only common sense that, in general, all of the drawings in a set should be of the same quality or level of drafting practice To help decide what level of drafting practice is most appropriate for a particular set of drawings, two questions must be answered: Who will use the drawings and what do the drawings represent? These questions will usually give rise to many more:

1. What manufacturing facilities are required?
2. Will replacement parts be needed?
3. How many are to be made?
4. How are parts to be inspected?
5. Are complete assemblies tested?

A careful review of all the contributing factors is the first step in the process of making a set of drawings.

EFFICIENT PRACTICE

If two draftsmen were independently to make the same drawing, it is most likely that (1) the drawings will be different and (2) one drawing will take much less time to make than the other. A comparison of the two drawings will, in effect, be a comparison of the practice of one draftsman with another. Depending on the combination of readability, completeness, correctness and time required to make, one of the drawings could probably be judged as better than the other. In other words, one of the draftsmen used a more efficient practice.

There are numerous equivalent conventions, techniques of graphical representation, methods of dimensioning, handling of explanatory notes, and arrangements for formats. Draftsmen should be constantly urged to use economical, standardized practice. Where draftsmen are familiar with all variations of established practice there should be no problems in carrying through this recommendation.

In the last few years many new drafting concepts have been introduced. Many of these are not universally applied by industry. Some of the ideas, such as leaving out arrowheads, using description instead of illustrations, avoiding hand lettering, etc., have caused much discussion. A great deal has already been said for and against these practices as they were developed through efforts to speed and simplify drafting. Only one point seems worthwhile mentioning here. If experience shows that a new convention, method, or technique significantly improves on those currently established, then it, in turn, will become the preferred practice.

Some general recommendations for efficient drafting practice are given separately. These are not hard-and-fast, but may serve as a checklist or guide in developing a system. The value of any recommendation depends on how applicable it is to the specific situation. Many examples would have to be shown to explore adequately the uses and limitations of these recommendations. Each different set of circumstances would lead to different results. This fact limits the generality of the comparison of the rival practices shown in Fig. 2. Where draftsmen are familiar with all variations of established practice there should be no problems in carrying through this recommendation.

THE PERSONAL FACTOR

In many ways, drafting practice cannot be divorced from the background and personal traits of the individual draftsman. This fact has great importance in the establishment of a preferred set of methods and techniques for a drafting department. However, practices can be developed which satisfy the requirements and are acceptable compromises betwen individualistic preferences and work habits.

Merely observing the forms of efficient practice does not insure that a significant saving in cost of making drawings will be realized. Techniques of efficient practice only provide the possibility for savings—not the realization. Sensible drafting, therefore, requires from an individual both the desire to work well and the ability of being able to work well. It is management's task to provide the facilities, the incentive, and the leadership.

Drafting ability of the individual is a product of training, experience, and inherent capacity. This includes the capacity to learn, to discriminate, to work well, to solve problems, and to do creative thinking. The measure of a person's ability is reflected in the work he is held responsible for, the pay he receives, and his status in the organization.

Ability is closely related to attitude, and attitude to productivity. A draftsman must have the proper attitude toward what he does; he must not feel that his job is merely to produce drawings. Drawings, however necessary, are not end products, but merely instruments used in the building of a machine, a tool, a structure, or a part. A better drawing should not mean a drawing with more artistic merit. It should mean a drawing that is

readable, complete, correct, unambiguous, and representative of good design.

In order to exercise his ability, a draftsman needs a good place to work, efficient equipment and suitable tools. A characteristic of most drafting operations is the need for referring to large drawings, bulky catalogs, handbooks, data sheets, and so forth. All these take reference and storage space. An efficient, well-arranged work sheet should be provided for each man.

It is possible to draw attention to almost any number of personal, technical, and organizational factors that have an effect on the productivity of a drafting operation. Drafting managers should look at what is being done in their departments and decide whether or not there is room for improvement. Nor should this process of self-criticism be limited to industry. Educators should be among the first to evaluate any new or different practices and to discard methods that have become obsolete. Most important of all, the people who use the language of drawings in their daily work must understand the significance of the changes of this language and be ready to appraise and judge the merit or inadequacy of both established and newly proposed practice.

General Recommendations For

EFFICIENT DRAFTING PRACTICE

Format

1. Don't clutter the drawing with nonessential signatures, revision blocks, general tolerance tables, parts-list headings, etc.
2. Be sure that the drawing number can be easily read when (1) the master is filed; and (2) when prints are folded and filed or bound in sets or books.
3. Provide adequate binding margins.

The Picture

4. Draw the simplest picture consistent with clarity and readability. Omit details, cross hatching, sections, or entire views if they are neither necessary nor make the drawing easier to read.
5. Do not overconcentrate information. If possible use two or more simple views in place of a single complicated one.
6. Avoid difficult projections by either making use of simplifying conventions or by a more convenient choice of sections, partial and auxiliary views, etc.
7. Line-work on a drawing should give clear, easy-to-read prints. This is the only requirement that should govern the weight of solid lines, dotted lines, center lines, etc.
8. Produce the picture by the easiest method practical. Trace over existing drawings or layouts. Use photo-reproduction techniques if applicable. Whatever method is used, avoid laboriously transferring dimensions from one drawing to another merely to "construct a picture."
9. Use the most convenient scale or scales. The use of distorted scales should be allowed where the resulting drawing is easier to read.
10. Drawings should be accurately drawn to full scale if it is practical to use prints in the shop as templates.
11. Group the various views and sections on a large drawing so that size and shape can be easily seen in three dimensions. For instance, the view that shows the location and diameter of a hole and the view that shows the depth of the hole should be placed as near to each other as possible.

Dimensions

12. Functional dimensions should be systematically derived and carefully checked.
13. Wherever possible, dimensions that locate or describe a particular feature or part of the unit should be grouped together.
14. Use the fewest possible base surfaces to dimension from, consistent with the need for controlling functionally related surfaces and the requirements of manufacturing and inspection.

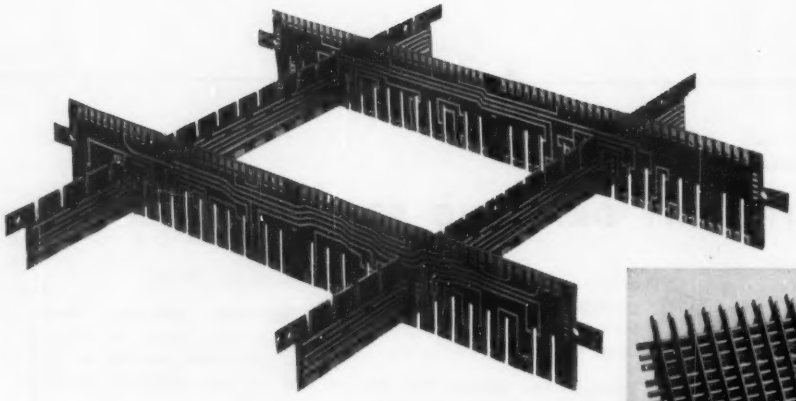
Notes

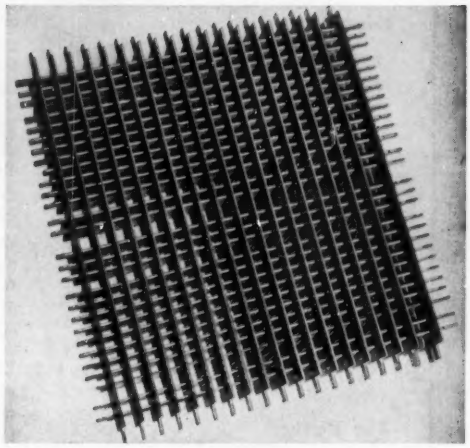
15. Standardize the wording of frequently used notes.
16. Lettering need only be neat and legible. No arbitrary standard of size or form should be insisted upon.
17. Use abbreviations sparingly unless it is known that all possible users of a drawing are familiar with them. There is little gain in saving a few seconds by abbreviating a word if someone may take an hour to find out what the abbreviation means.

General

18. Use the smallest possible standard-size sheet without crowding information.
19. Avoid duplicating information in any form.

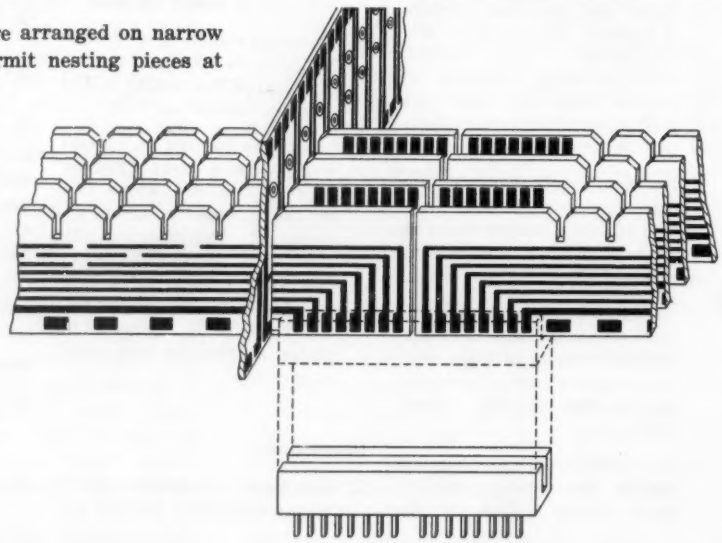
scanning the field for *ideas*

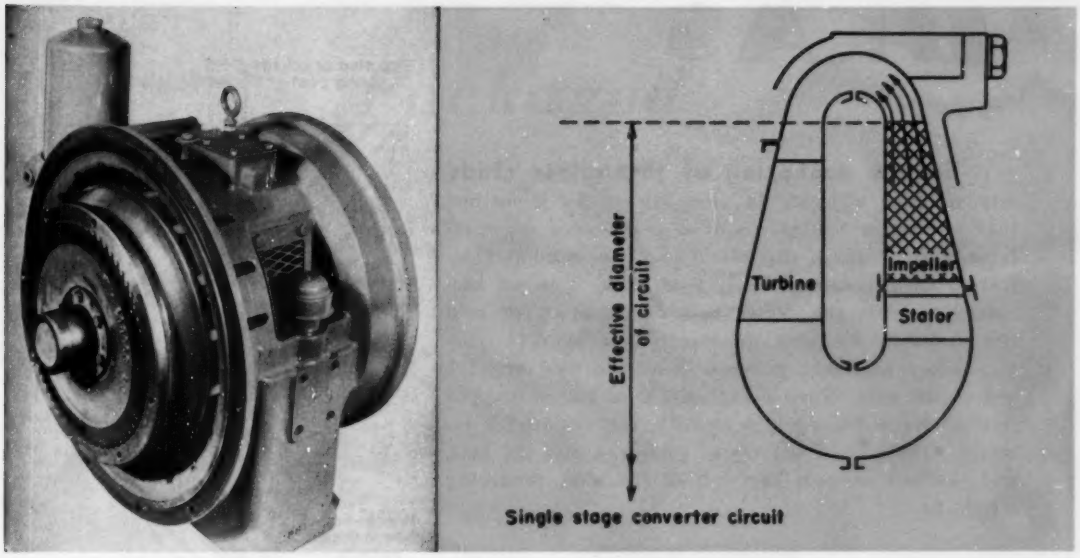




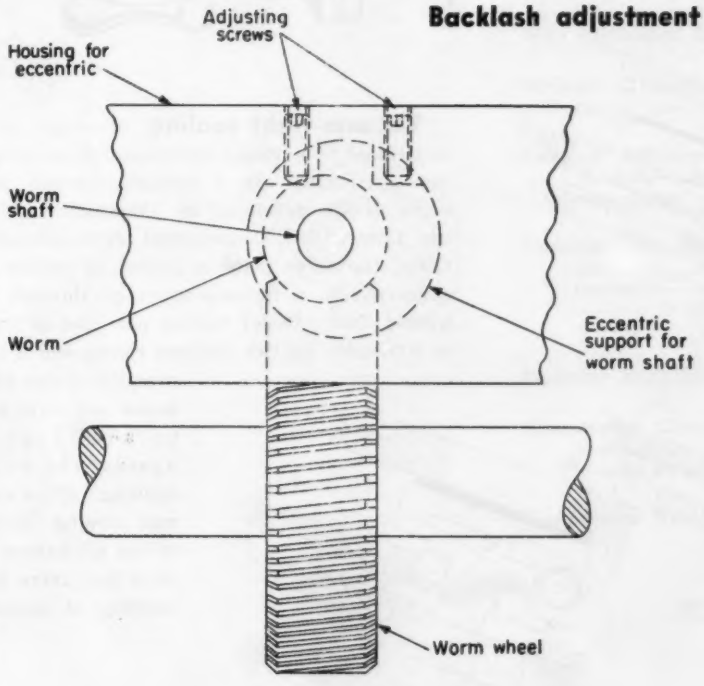
Three-dimensional printed circuits simplify complicated wiring interconnections and circuit packaging. As reported by E. R. Wyma in the January, 1957 issue of the *IBM Journal of Research and Development*, the three-dimensional arrangement is used in the design of printed back panels in the IBM 608 transistorized computer. One such array serves the function of 650 wires and sockets and holds 36 plug-in circuit cards.

In this system, conductors are arranged on narrow strips which are slotted to permit nesting pieces at right angles. When conductors must connect at strip junctions, conductor paths are brought together on the same level at the corner. The entire circuit is prepared in this manner and all circuit strips assembled. The assembly is immersed in a solder bath which wets the conductors and fillets in the corners where two conductors meet, completing the electrical circuit.





Pear-shaped fluid circuit in Twin Disc torque converter, combined with a novel turbine-blade design, automatically unloads converter from engine as turbine speed approaches impeller speed. Under these high speed ratio conditions fluid circulation is stopped through the hydraulic balancing of a head developed by the impeller and a counterhead produced by the turbine. This feature provides an intergral means of limiting output speed without using a converter output-shaft governor and simplifies construction by eliminating free-wheeled stators. The pear-shaped fluid circuit in these new 1300 series units permits converter fluid to leave the impeller blades at constant diameters.

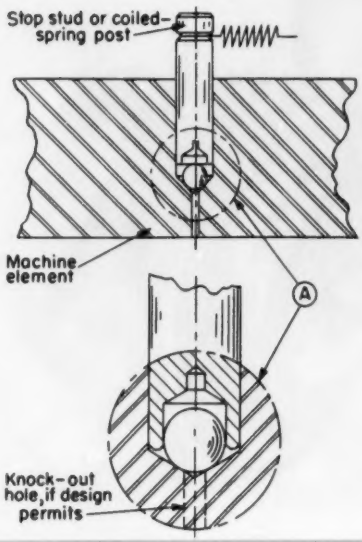


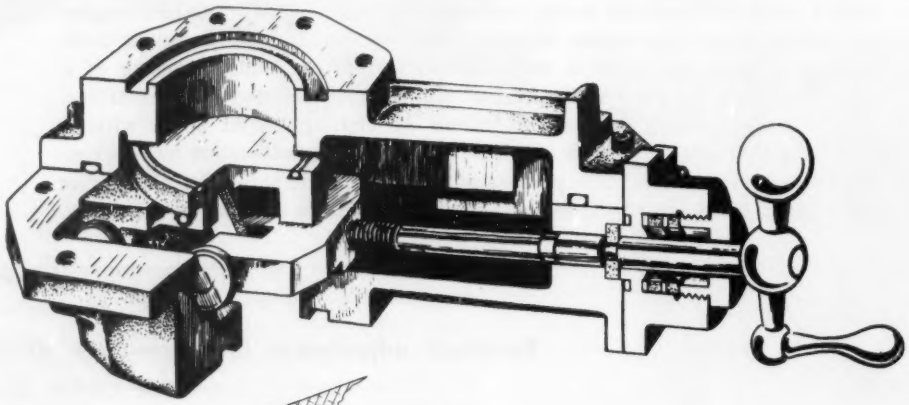
Backlash adjustment in worm-gear drives is provided by a novel eccentric mounting arrangement developed by Clint McLaughlin, Queens, New York. Ends of the worm shaft are mounted in eccentric supports. Gear mesh is adjusted by rotating each eccentric in the appropriate direction by loosening one setscrew and tightening the other.

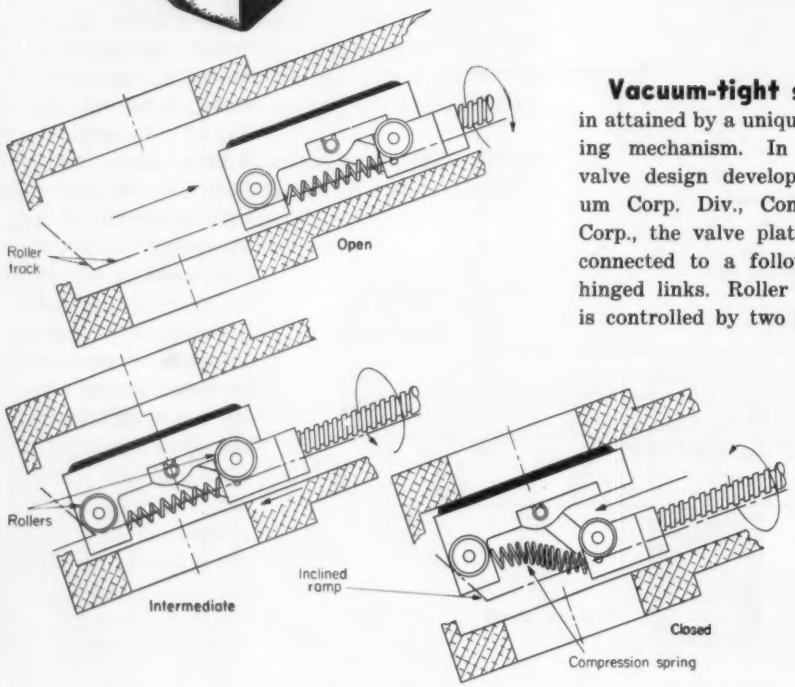
IDEAS

Secure anchoring of threadless studs into machine elements is accomplished by a method that eliminates the need for close-tolerance or interference fits. In a drive-fit technique developed by Harold Blye, Bellerose, L. I., New York, it is not necessary to ream the drilled hole for accuracy or hold the stud-body diameter to close tolerances.

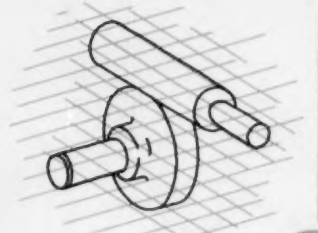
Before assembly, a center hole is drilled into the end of the stud. Then a hardened steel ball is dropped into a hole in the machine member, and the stud is inserted. The stud is hammered or forced into the hole, and the ball expands the wall of the stud, producing a tight fit.

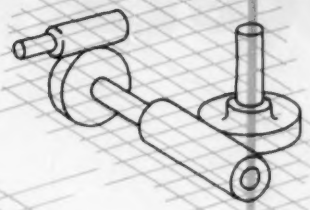


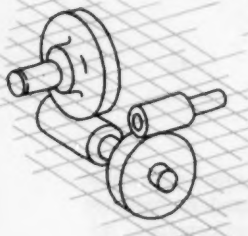


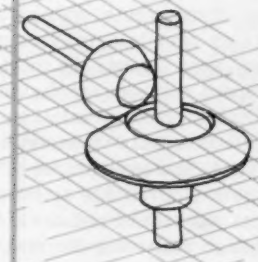


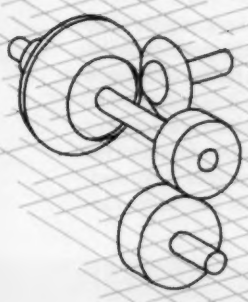
Vacuum-tight sealing of valve plates in attained by a unique roller-and-linkage actuating mechanism. In a straight-through gate-valve design developed by Consolidated Vacuum Corp. Div., Consolidated Electrodynamics Corp., the valve plate is guided by rollers and connected to a follower carriage through two hinged links. Roller motion near end of travel is controlled by two inclined ramps and a compression spring which raises the valve plate to seal tightly against the valve opening. Opening and closing motions of the mechanism are such that there is no scuffing of gasket.

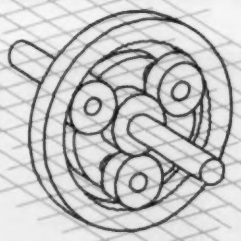


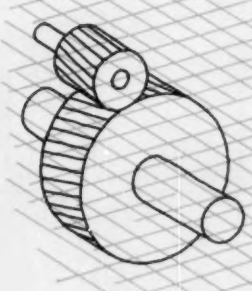


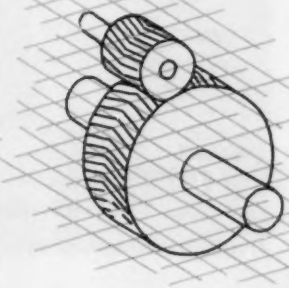












Packaged Speed Reducers *and* Gearmotors

William S. Miller
Associate Editor, Machine Design

In a profusion of "standard" types, geared speed reducers and gearmotors offer almost unlimited choice in design. As an aid in sorting them out and matching them to drive requirements, this comprehensive guide focuses attention on these points. . .

Why Packaged Reducers?

Reducer Classification
Gearing type—shaft orientation—stage arrangement

Reducer Performance Rating
Mechanical rating—thermal rating—torque rating—overhung load—reduction ratio

Reducer Selection Factors
Ratio vs type—ratio vs efficiency—overhung-load capacity—mounting style—reducer weight—cooling auxiliaries—backstops—torque limiters—shear couplings

Reducer Installation

Gearmotor Classification
Shaft orientation—gearing type and arrangement—mounting styles—motor types—accessories

Gearmotor Selection Factors

How to select and apply

speed reducers

POWER-TRANSMISSION requirements that argue a strong case for the geared fixed-ratio speed reducer serve equally well to define its function: smooth multiplication of torque and reduction in speed between driving and driven shafts, plus permanent and precise synchronization of shaft speeds and angles.

Other mechanical drives—belts and chains, for example—can, in some of their forms, satisfy these specifications. Choice of the best system for a given application will usually hinge on the outcome of a careful evaluation of drive performance, efficiency, flexibility, durability and cost.

If somewhat higher in first cost than the simpler drive systems, the fixed-ratio geared speed reducer demonstrates counterbalancing advantages that are common to gearing in general:

1. Shock-free transmission of power.
2. Precise synchronization of input and output shafts.
3. High or creditable efficiency at all speeds and reduction ratios.
4. Compactness and flexibility of component arrangement.
5. Low noise level and long life.

In this article, presented as a guide to fixed-ratio speed reducer and gearmotor selection, emphasis centers on available types, performance characteristics and rating methods of catalog-standard or so-called packaged units.

Why Packaged Reducers?

Standard speed reducers—manufactured in a botanical-like variety of types, configurations and capacities—offer the designer a compact and economical means for changing the direction and velocity of shaft power. Where use is feasible from an engineering standpoint, standard reducers often demonstrate substantial performance advantages over integrally incorporated or "built-at-home" gear trains. In most cases, catalog-standard speed reducers are designed in compliance with applicable recommendations of AGMA. Such standards ensure conservative selection of both materials and proportions of reducer parts.

Another advantage accruing to the designer who selects a standard reducer is certified performance. Although reflecting the manufacturer's confidence in his product, such performance guarantees are not offered as blanket-coverage insurance against every possible reducer failure. Rational selection and application of the product are still expected. A representative catalog statement of manufac-

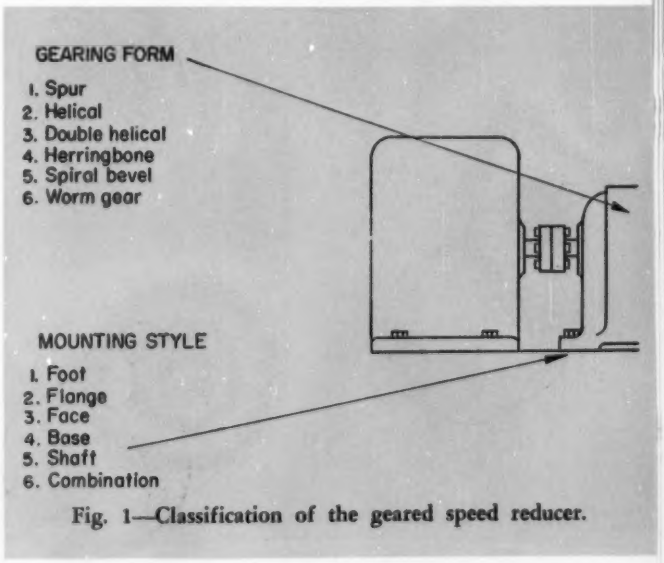


Fig. 1—Classification of the geared speed reducer.

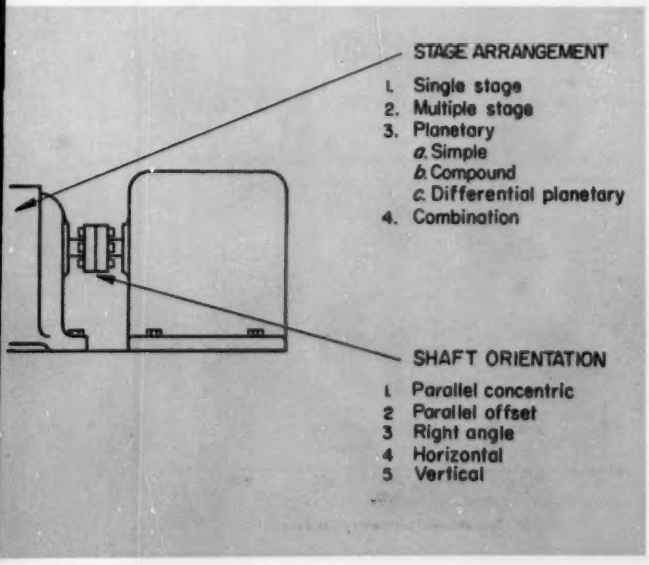
and gearmotors

turer's responsibility spells out the conditions under which it is issued:

> Responsibility for satisfactory operation of gear reducers is assumed by the manufacturer, providing the unit is properly installed and lubricated and loads are within the rating of the drive.

Standard vs Special Reducers: In selecting a reducer, the designer will obviously specify a standard catalog model if possible. Both first cost and delivery time of special or modified-standard units argue this point. It is recognized that space limitations, unusual shaft arrangements, or the need for combination drives will, on occasion, dictate the use of special or nonstandard reducer housings.

In such event, the most economical nonstandard reducer is one designed and built around standard bolt-hole circles, employing standard mountings, and incorporating parts that can be fabricated on existing tooling. Large savings are also realized when gear and bearing-mounting hardware, as well as shaft center distances, can be standard.



Reducer Classification

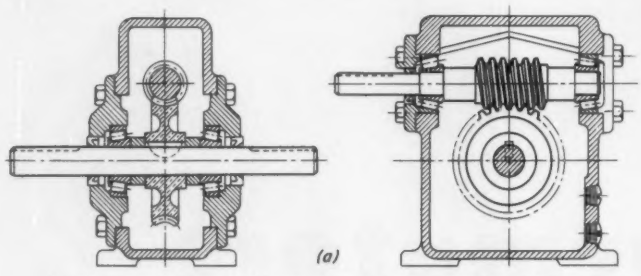
Descriptive classification of packaged speed reducers follows an industry-accepted pattern that, while well defined, is subject to continuing expansion and subdivision as new reducer types and configurations are introduced.

Primary categories establishing the salient physical design features of reducers are: (1) gearing type, (2) shaft orientation, and (3) stage arrangement, Fig. 1. From a performance standpoint, manufacturers further identify each reducer type by reduction ratio, power and torque ratings, input speed, and overhung-load capacity. Often, the mounting arrangement of the reducer becomes a classification element. For example, shaft-mounted, foot or flange-mounted, and shovel-base units are some of the types that are available.

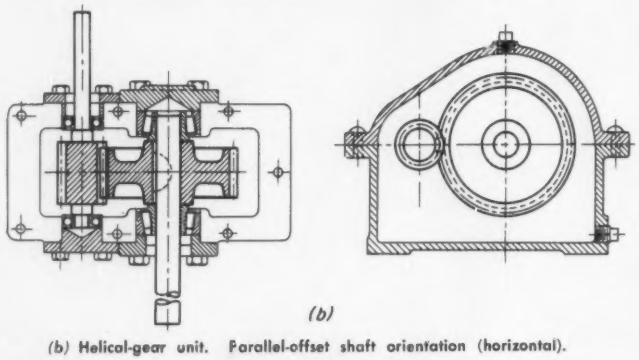
Gearing Type: With respect to basic gearing employed in packaged speed reducers, these major forms are widely used:

1. Spur
2. Helical
3. Double helical
4. Herringbone
5. Spiral bevel
6. Worm gear

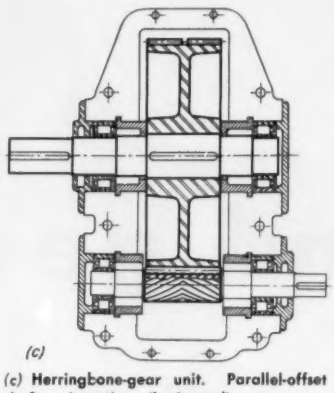
Performance characteristics of basic gearing forms help rough out areas of their best application. Evaluation of speed, power-transmission levels, efficiency required, shaft orientation and cost is essential before a particular gearing form can be specified.



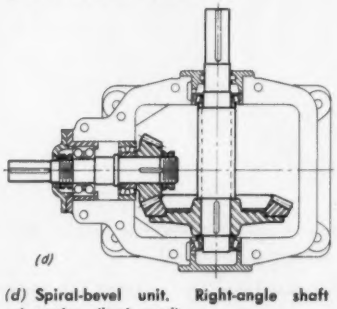
(a) Worm-gear unit. Right-angle shaft orientation (horizontal).



(b) Helical-gear unit. Parallel-offset shaft orientation (horizontal).

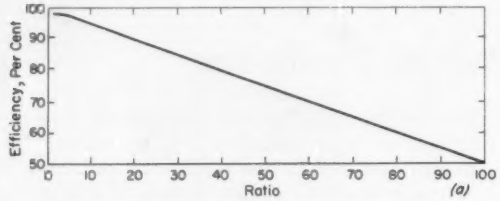


(c) Herringbone-gear unit. Parallel-offset shaft orientation (horizontal).

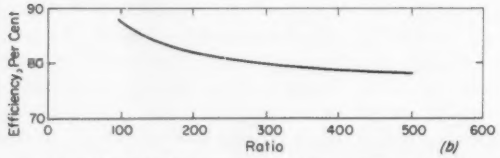


(d) Spiral-bevel unit. Right-angle shaft orientation (horizontal).

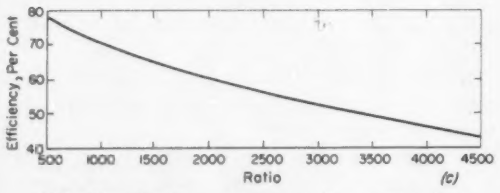
Fig. 2—Typical single-reduction stage arrangements for basic gear forms.



(a) Single-reduction worm-gear reducer (vertical or horizontal right angle).

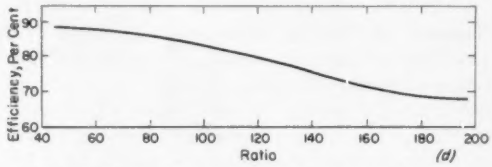


(b) Double-reduction worm-gear reducer—ratios to 500:1 (parallel or right angle).

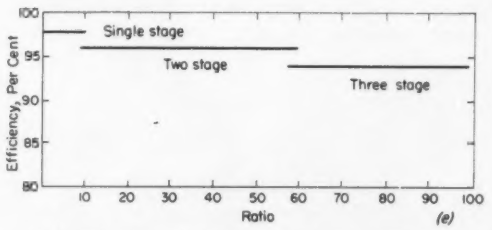


(c) Double-reduction worm-gear reducer—ratios from 500:1 to 4500:1 (parallel or right angle).

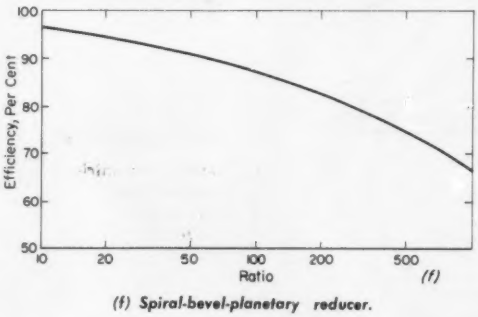
Fig. 3—Efficiency as a function of reduction ratio for various reducer types and stage arrangements. Values given are approximate and assume operation within rated reducer capacity, with proper lubrication and at normal ambient temperatures.



(d) Helical-gear first stage, worm-gear second stage (right angle horizontal or vertical).



(e) Single and multiple-stage helical and herringbone reducers.



(f) Spiral-bevel-planetary reducer.

Shaft Orientation: Often a major factor to be considered in the speed-reducer selection process, shaft orientation is described as:

1. Parallel offset
2. Parallel concentric
3. Right angle
4. Horizontal or vertical

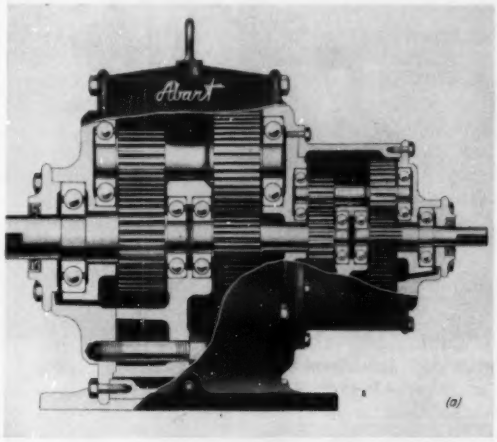
In not all reducer applications will space limitations or mounting convenience be the deciding factors that establish shaft orientation. As illustrated in a subsequent section, certain performance considerations—for example, reduction ratio—may lead to compromise in the choice of reducer input and output-shaft positions.

Stage Arrangement: Limits on maximum reduction ratios attainable with single-stage gearing, Fig. 2, are set either by practical limitations on gear size, or by factors that relate to efficiency or performance. Single-stage helical and herringbone reducers, for example, are usually supplied in ratios not much higher than about 10:1 to keep gear sizes within practical limits. In the case of single-reduction worm-gear units, speed ratios rarely exceed about 100:1. This is because high ratios require low worm-lead angles with resulting low efficiencies, Fig. 3.

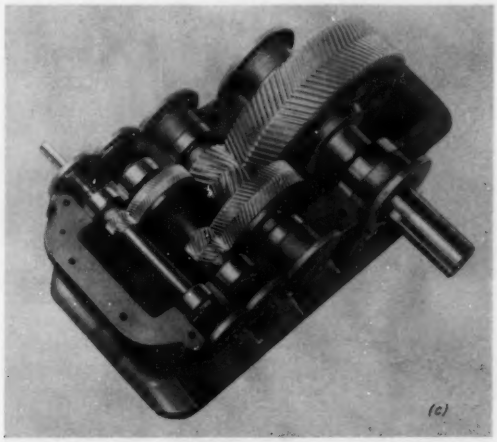
In multistage versions of the basic gear forms, Fig. 4, reduction ratios for each stage are held to values that ensure acceptable overall efficiency.

To provide ratios intermediate between those provided by single and two-stage gearing, or to reorient input or output-shaft direction, basic gear types are often crossbred into combinations like those shown in Fig. 5. Such combinations may yield advantages in efficiency, size or price over

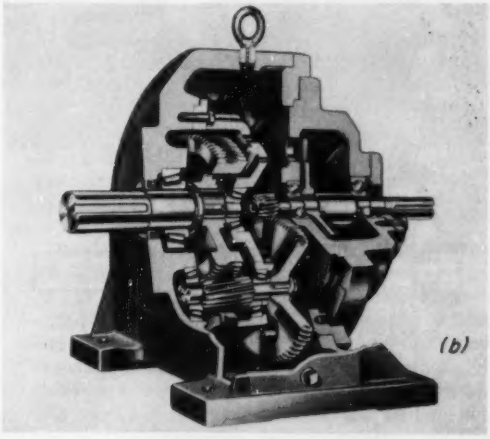
(*Text Continued on Page* 128)



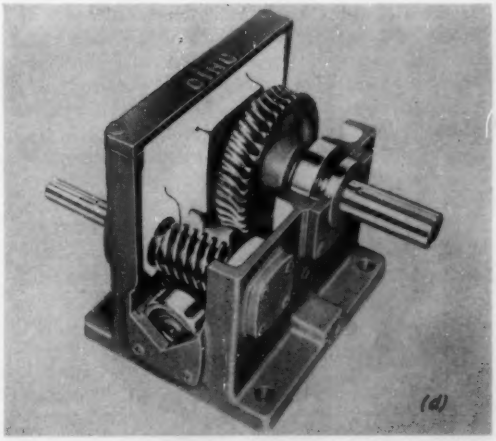
(a) Four-stage spur-gear reducer, parallel-concentric shaft.



(c) Three-stage herringbone-gear reducer, parallel-offset shaft.

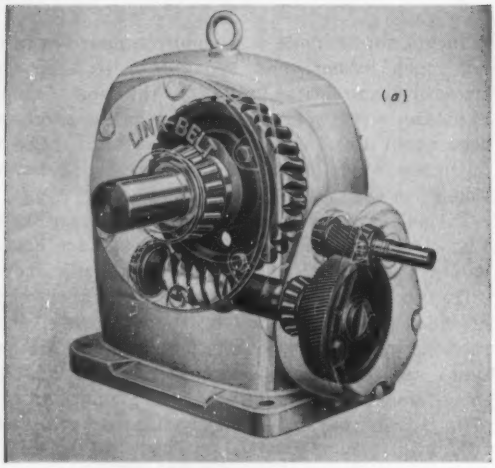


(b) Two-stage helical-gear reducer, parallel-concentric shafts.

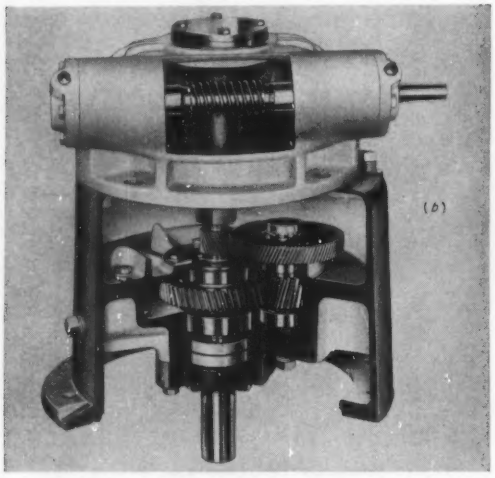


(d) Two-stage worm-gear reducer, parallel-offset shaft.

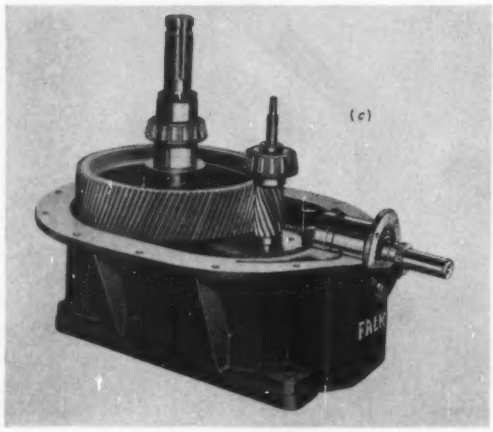
Fig. 4—Typical multistage arrangements for basic gear forms.



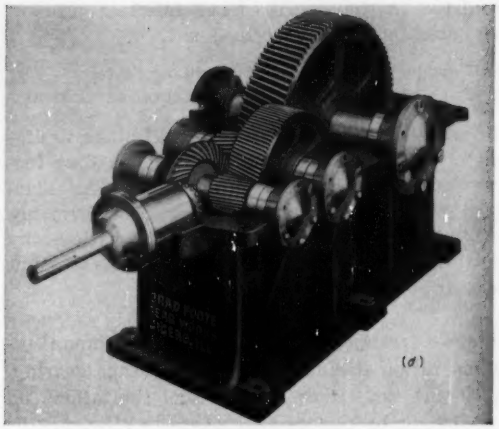
(a) Helical-gear first stage, worm-gear second stage.



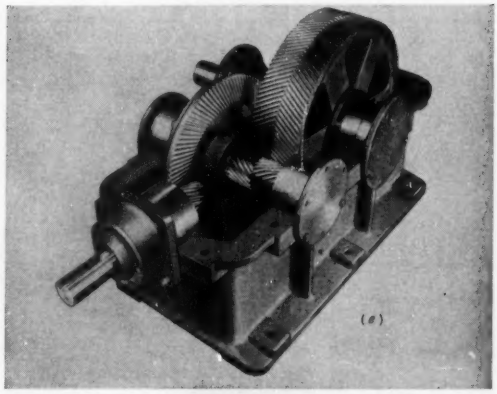
(b) Worm-gear first stage plus two-stage helical gearing.



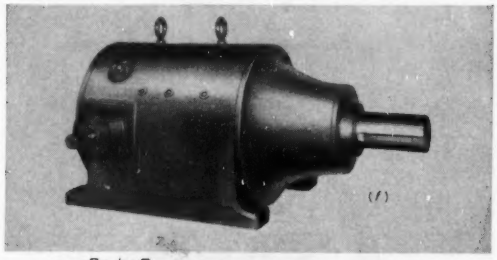
(c) Spiral-bevel first stage plus single-stage helical gearing.

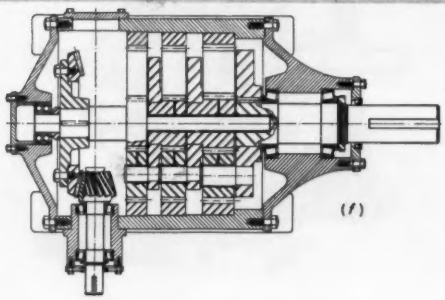


(d) Spiral-bevel first stage plus two-stage helical gearing.



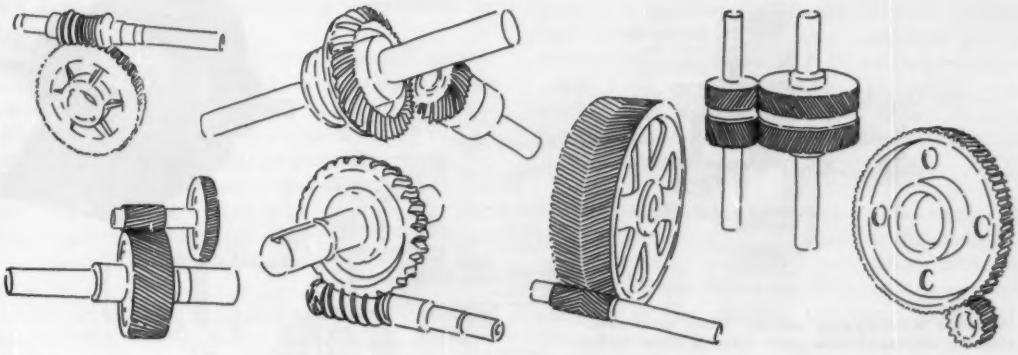
(e) Spiral-bevel first stage plus single-stage herringbone gearing.





(f) Spiral-bevel first stage plus planetary gearing.

Fig. 5—Typical multistage combinations of basic gear forms.



Basic Gear Sets

Spur Gears: Practical reduction ratios attainable with single-stage spur-gear sets, used for speed-change between parallel shafts, range up to about 10:1. Principal advantage of spur gearing is its ability to transmit power without end thrust or axial displacement. Although efficiency of spur-gearing is high—reaching 99 per cent where an oil bath is provided—it is inclined to be noisy at pitchline velocities exceeding 1000 fpm. Use is therefore more general in reducers intended for moderate-speed use. Because instrument-quality spur gears are available from stock in a wide range of diametral pitches, they are frequently employed in precision miniature reducers of the type used in servo-control systems.

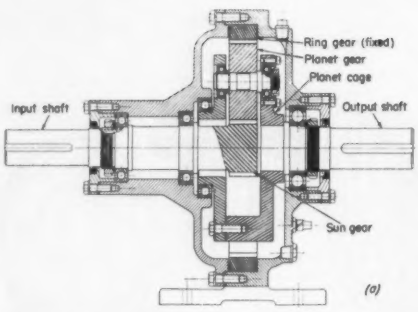
Helical Gears: The staggered or inclined-tooth construction of the helical gear—constituting, in effect, a stack of slightly displaced, infinitely thin spur gears—results in progressive transmission of load from tooth to tooth. Such action reduces momentary accelerations and shocks that are noise sources in simple spur gears. Because there is always tooth contact at the pitch line, helical gearing transmits motion at essentially constant angular velocity. Higher pitch-line velocities are also possible with helical gears than with spur gears, reaching values to 9000 fpm or greater. Thrust loads resulting from the "cork screw" action of helical gearing are appreciable and must be carried by bearings of suitable thrust capacity. Maximum helical gear ratios and efficiencies are approximately the same as for spur-gear sets.

Double-Helical Gears: In the double-helical gear, two sets of opposed helical teeth are cut on the same blank. Because side thrusts are cancelled by the balanced thrust of opposing helices, size of thrust bearings and thickness of thrust-resisting housing sections can be decreased. Efficiency, which depends upon speed, temperature and lubrication, ranges from 95 per cent or better in triple-reduction helical reducers to over 98 per cent in single-stage units. When double-helical gears are shaved and dynamically balanced, speeds up to 10,000 rpm and pitchline velocities to 9000 fpm or greater can be employed.

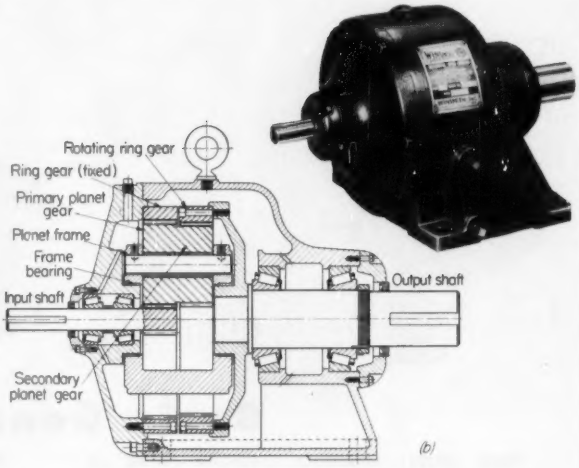
Herringbone Gears: Continuous-tooth herringbone gears are double-helical gears cut without a groove separating the two rows of teeth. Chief use is for transmission of heavy loads where shock or vibration is present, or where high reduction is required in a single stage. Pitchline velocities range up to 4000 fpm. Like the double-helical gear, the herringbone gear produces no end-thrust problems. Although it is not practical to shave continuous-tooth herringbone gears, lapping produces a superior tooth finish and reduces operating noise to a minimum.

Spiral-Bevel Gears: Used for right-angle direction change in packaged speed reducers, or to provide intermediate ratios when in combination with other gearing types, spiral-bevel gears are superior to straight-tooth bevel gears because the load is distributed over more teeth. Thrust loads, which are greater than for straight-tooth bevel-gear sets, vary in axial direction with changes in rotation of pinion and gear. Efficiency depends upon ratio, speed, and load, and ranges from about 94 per cent to 98 per cent. Ratio limit for a spiral-bevel set is about 6:1.

Worm Gears: Advantages of smooth tooth action, flexibility of arrangement, and load-carrying capacity inherent in worm gearing accounts for its widespread use in packaged speed reducers. Higher ratios can be attained through use of worm-gear sets on a given center distance than with any other type of gearing. Thus, the number of moving parts in the reducer is cut to a minimum. Because worm and gear teeth are under crushing rather than cantilever loads, the combination has high resistance to shock. To be distinguished from conventional worm gearing, in which the gear envelopes the worm, are double-enveloping worm-gear sets, in which the gear envelops the worm and worm envelops the gear. In this arrangement, which brings more gear teeth into contact with the worm, the worm has an hourglass rather than the conventional cylindrical shape. Efficiency of worm gearing depends chiefly upon the lead angle of the worm, with efficiency increasing as lead angle and ratio increase. Efficiency ranges from 60 to 95 per cent, depending on ratio.



(a) Simple planetary-gear reducer. Planet gears simultaneously engage the sun gear, which is keyed to the input shaft, and the fixed ring gear. Rotating freely around their axes in the planet cage, planet gears move concentrically around the gear-box axis, rotating the planet cage and output shaft.



(b) Planetary-differential reducer. Torque path is through the input-shaft sun gear to the primary planet gears, which engage both the sun and fixed ring gears. Rotation and translation of secondary planet gears, which are integrally mounted with the primary planets, rotates the secondary ring gear and output shaft. Unit here provides ratios from 1.1:1 to 50,000:1; power rating ranges from 0.12 to 81.5 hp.

Fig. 6—Planetary-gear reducers offer an almost unlimited variety of speed ratios between driving and driven members. Shown here are simple planetary and planetary-differential reducers.

those employing tandem or multistage arrangements of a single gearing type. For example, overall efficiency of a helical-worm reducer with 72:1 ratio is about 85 per cent. This efficiency is the product of the individual efficiencies of worm and helical stages. On the other hand, corresponding efficiency of a single-reduction worm-gear reducer with 72:1 ratio is only about 70 per cent.

To be distinguished from conventional multistage reducers—where high ratios are attained by simply lining up gear sets in tandem—are planetary, compound-planetary, and differential gearing arrangements, Fig. 6. Such reducer types are available in ratios ranging from close to 1:1 to 50,000:1 or higher.

Reducer Performance Rating

Surefire prescription for an unsatisfactory speed-reducer installation—if not for actual reducer failure—is to select the reducer without completely understanding the basis of its performance rating. Although not particularly complex, the selection problem involves more than just establishing an exact one-to-one agreement between stated mechanical rating of the reducer and steady-state power requirements of the driven machine.

Some hint as to the breadth of the reducer rating system is given by the extensive footnotes that frequently accompany the manufacturer's performance rating page. Here is a list of typical qualifications:

1. Mechanical ratings apply only for a service factor of 1.0.
2. Mechanical ratings are shown in color when they exceed thermal ratings.
3. Torque ratings should be evaluated at high ratios or at low input speeds.
4. Overhung-load ratings assume load application at center of reducer shaft extension.
5. Standard ratios listed vary plus or minus 3½ per cent.

In following paragraphs, key phrases appearing in such typical performance notes are defined and related to the speed-reducer rating process.

Mechanical Rating: In an evaluation of power-transmission capacity of a speed reducer, clear distinction must be drawn between *actual power* and *equivalent power*.

From the standpoint of reducer rating convention, actual power is related directly to *steady-state* requirements of the driven-machine. Calculated, for example, as the product of driven-machine torque times speed, actual power has no built-in factor that provides for possible shock-loading effects, nor is it concerned with the continuous or intermittent nature of the duty cycle.

Although suggested procedures vary, driven-machine power is normally converted to reducer input power by dividing machine power by anticipated reducer efficiency.

In contrast to actual power, equivalent power makes full allowance for expected shock characteristics of the prime mover and load and for the number of hours per day that the reducer will operate. It is obtained by multiplying actual power (converted to reducer-input terms) by an AGMA recommended service factor, Table 1. Such factors modify actual power to a degree that depends upon (1) smoothness of power transmitted to the re-

ducer by the prime mover, (2) shock characteristics of the driven machine, and (3) nature of the duty cycle, whether representing continuous or intermittent operation.

In accordance with AGMA recommended system, mechanical ratings tabulated in reducer catalogs assume a service factor of 1.0. As a basis for selection, therefore, catalog mechanical rating can be matched directly to *actual* power only where the driven load is completely shock-free, where the duty cycle does not exceed 8 to 10 hours per day (continuous operation), and where the prime mover is an electric motor or similar shock-free power source.

Under all other application conditions—that is, wherever the service factor exceeds 1.0—reducer selection must be based upon the calculated *equivalent* power. For example, assuming *actual* power required at a reducer input shaft is 5 hp and the AGMA recommended service factor is 1.3 for the application, then *equivalent* load is equal to 1.3×5 or 6.5 hp. In this example, as in all other speed-reducer applications, the reducer selected must have a catalog mechanical rating that equals or exceeds the calculated equivalent load.

To facilitate design decision as to the shock characteristic of a particular reducer application—a decision that prefaces determination of the service factor—certain typical equipment applications are classified as either uniform, moderate-shock or heavy-shock in the AGMA standard that applies to the reducer type under consideration.[1-6] Pure-liquid agitators, for example, are classed as uniform (shock-free) loads for herringbone-gear reducers. An ore crusher, on the other hand, represents a typical heavy-shock application. Naturally, definite decision as to the shock character of the load can only be made with full knowledge of actual operating conditions that exist for an application.

Beyond consideration of shock-loading characteristics, evaluation of the effects of momentary or starting overloads on a reducer is essential. Reducer gearing is usually designed to AGMA practices and will withstand repeated short-duration overloads not in excess of 20 per cent of rated or normal load (100 per cent overload). As a check on reducer adequacy in a potential application with known momentary overloads, a new equivalent load is obtained by dividing maximum predicted overload by the factor 2.0. If the new equivalent-power value exceeds the value obtained by consideration of shock-loading and duty cycles only, it becomes an overriding factor and must be used as the basis for speed-reducer selection.

Thermal Rating: Friction in bearings, gear-tooth sliding and oil churning in the housing all raise the temperature of a reducer oil bath. Highest local temperatures are found at the contacting surfaces of the gearing, but rapid movement of these parts in the oil bath and agitation of the oil minimize temperature differences between the gearing mass and the oil bath. Such oil churning, incidentally, represents a significant power loss in the reducer. Because this loss is independent of load, reducer efficiency decreases with reduction in load.

Tests show that, when a reducer has reached peak stable temperature, oil throughout the reducer is at substantially constant temperature. Moreover, temperature of the housing walls is approxi-

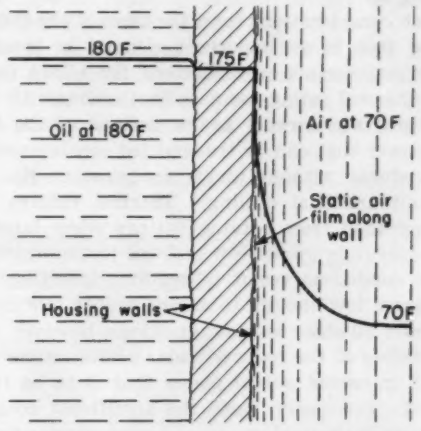


Fig. 7—Temperature profile through typical reducer oil-bath and housing section.

[1]References are tabulated at end of article.

Table 1—Service Factors for Helical and Herringbone Reducers

Prime Mover	Duration of Service	Load Classification: Uniform Load	Moderate Shock	Heavy Shock
Electric motor or Steam turbine	*Occasional, ½ hr per day	0.50	0.80	1.25
	*Intermittent, 3 hr per day	0.80	1.00	1.50
	Continuous, up to 10 hr per day	1.00	1.25	1.75
	Continuous, up to 24 hr per day	1.25	1.50	1.75
Multicylinder internal combustion engine	*Occasional, ½ hr per day	0.80	1.00	1.50
	*Intermittent, 3 hr per day	1.00	1.25	1.75
	Continuous, up to 10 hr per day	1.25	1.50	2.00
	Continuous, up to 24 hr per day	1.50	1.75	2.00
Single-cylinder internal combustion engine	*Occasional, ½ hr per day	1.00	1.25	1.75
	*Intermittent, 3 hr per day	1.25	1.50	2.00
	Continuous, up to 10 hr per day	1.50	1.75	2.25
	Continuous, up to 24 hr per day	1.75	2.00	2.25

*Maximum momentary or starting load must not exceed 200 per cent of catalog rating.

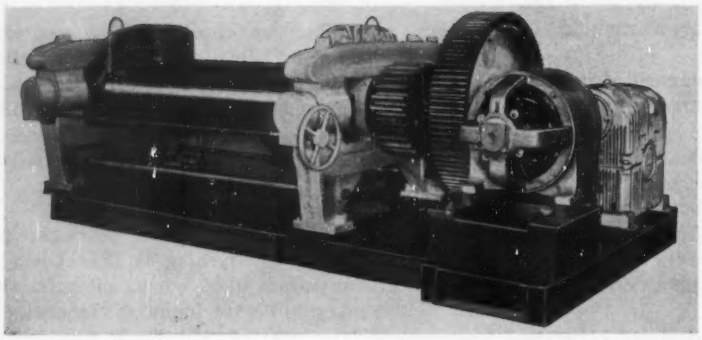


Fig 8—Reducer overhung-load capacity is an important rating factor where reducer-load coupling is through external gearing. Typical of such applications is this dog-biscuit dough roller, which handles sheets up to 86 in. wide. Built by Stewart Bolling & Co. Inc., the mill is driven by a 25-hp motor through a standard double-enveloping worm unit.

mately the same as that of the oil, unless forced-cooling accessories are used.

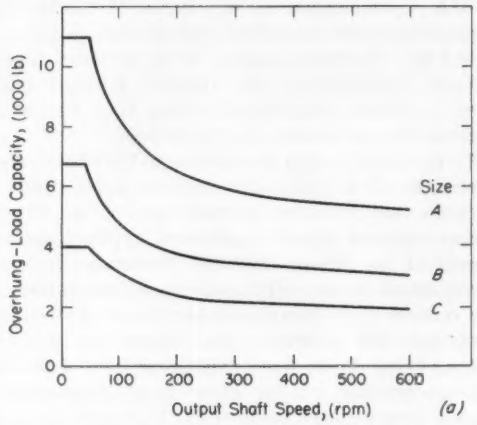
Typical temperature profile through a convection-cooled reducer housing is shown in Fig. 7. Agitated oil is 180 F on one side of the housing; air temperature is 70 F on the other. Quite obviously, at a given speed, two factors raise oil temperature and, therefore, temperature of reducer components: (1) increase in power transmitted by the reducer, and (2) increase in temperature of the ambient cooling air.

Such considerations form the basis of the *thermal rating* that is an important element in speed-reducer performance specifications. By AGMA definition, thermal rating assumes that ambient air temperatures are normal, and is defined as the average power that can be transmitted continuously by the reducer without undue temperature rise and without artificial cooling. Thermal ratings may be upgraded from catalog listings when intermittent operating cycles, low ambient temperatures, or other conditions result in reducer operating temperatures low enough to assure proper lubrication.

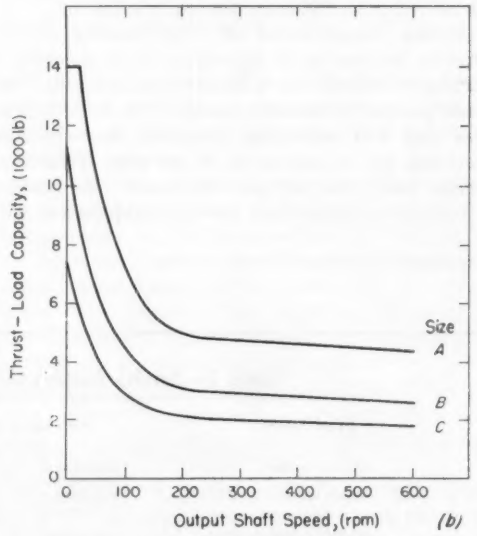
Under all other service conditions, however, *thermal rating* of the reducer under consideration must equal or exceed *actual power* that is to be transmitted. Obviously, since the significant comparison here is thermal vs actual power, service factors need not be considered in the evaluation.

Torque Rating: Input requirements for the driven machine in a reducer application are frequently expressed in terms of torque and speed, rather than power. Conversion of one data type to the other is, of course, quite simple. However, because output torque ratings are often tabulated in reducer manufacturers' literature, it may be equally convenient to select the reducer directly on a torque-rating basis. In such cases, equivalent torque is obtained by multiplying actual torque by the applicable load-characteristic factor.

Where application of a worm-gear reducer is contemplated, torque rating becomes an overriding factor under two conditions: (1) extremely high reduction ratios, or (2) extremely low reducer input or worm speeds. With high reduction ratios, torque multiplication between input and output shafts is often extreme, resulting in dangerously



(a) Allowable overhung loads on output shaft.



(b) Allowable thrust loads on output shaft.

Fig. 9—Overhung and thrust-load capacities of representative worm-gear reducers in three sizes.

high torque values in final gearing stages and at the output shaft. This effect is especially critical where sudden stalling of the driven load is a possibility. In worm-gear applications where reducer input speed is less than 100 rpm, static-load conditions are approximated from a reducer lubrication and cooling standpoint. Consequently, since tangential crushing loads on worm and gear teeth must be limited, it is usually recommended that the reducer be selected on an output-torque basis.

One additional application factor leads to evaluation of reducer torque capacity, namely, installation of a brake on the reducer drive motor. Because rapid buildup of inertial torque follows sudden application of the brake, torque rating of the reducer should always be equal or exceed torque rating of the brake.

Overhung Load: Shaft torque rather than bending loads is of principal concern where a speed reducer is direct-connected by flexible couplings to prime mover and driven machine. Where coupling is through gear, belt or chain drives, however, overhung load capacity of the reducer becomes a rating factor of importance, Fig. 8.

Allowable overhung load for a reducer, normally tabulated with other performance specifications, assumes that bending loads will be applied at the middle of the reducer shaft extension. Because bearing capacity decreases with increasing speed, allowable overhung-load values decrease correspondingly, Fig. 9*a*.

For a planned reducer installation, overhung shaft load may be calculated by transformation of transmitted power into equivalent overhung load by means of the equation

$$L = \frac{63{,}025\,PF}{nr} \qquad (1)$$

where L = equivalent overhung load, lb; P = transmitted power, hp; n = shaft speed, rpm; r = pitch radius of pinion, sprocket or pulley, in.; F = factor which depends upon the type shaft coupling to be used. AGMA recommended values for factor F are tabulated for chain, belt, and pinion drives in Table 2. The manufacturer's tabulated overhung-load capacity should always equal or exceed load L calculated from Equation 1.

Related to overhung-load capacity of a speed reducer is its ability to withstand external thrust loads. Thrust loads arise, for example, in an application where coupling of the reducer to the driven

Table 2—Overhung-Load Factors

External Drive	Factor, F
Single-chain sprocket	1.00
Double-chain sprocket	1.25
Spur pinion	1.25
V-belt sheave	1.50
Flat-belt pulley	2.50

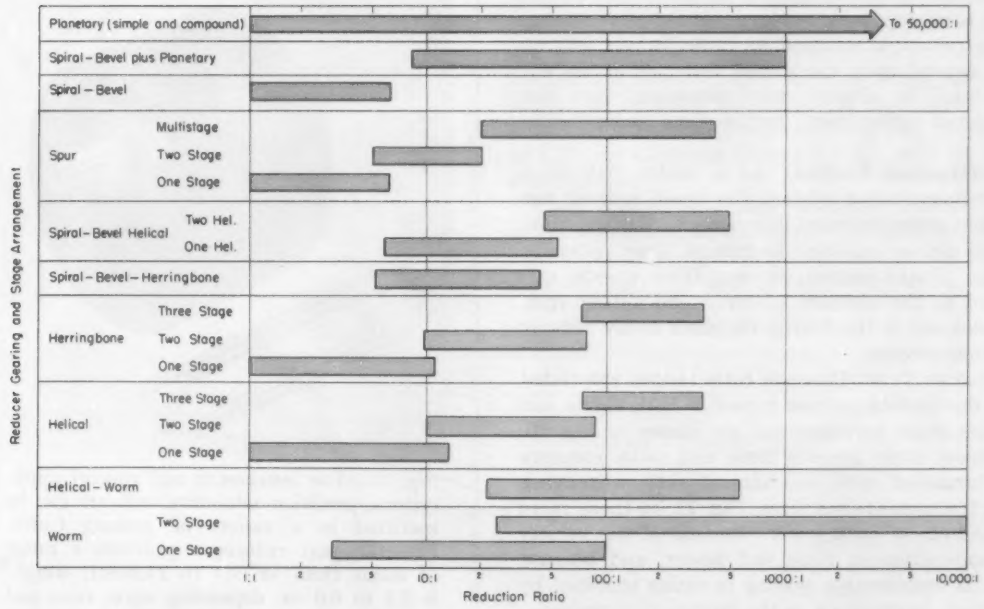


Fig. 10—Common ratio ranges associated with various reducer gearing types and stage arrangements. Limits shown are approximate. Higher or lower ratios can often be furnished in a given gearing type with moderate or no additional reducer cost.

machine is through external helical gearing. For the majority of reducers, thrust load, which is related to speed as shown in Fig. 9*b*, cannot be used at maximum value simultaneously with maximum overhung-load capacity. Should externally applied thrust loads and overhung loads each exceed 50 per cent of reducer capacity, the application problem should be referred to the reducer manufacturer.

Reduction Ratio: Basic information in the speed-reducer rating system is speed-reduction ratio, defined as the quotient of reducer input and output shaft speeds. Ratios tabulated by speed-reducer manufacturers are, in practically every case, approximate values. Should requirements of the application demand exact ratios, or perhaps ratios intermediate between those listed in the catalog, such nonstandard ratios can be supplied by most manufacturers.

Reducer Selection Factors

As a convenient approach to speed reducer selection—where variety of choice often presents a problem—major demands of the application can be grouped into two categories. In the first category are those factors concerned principally with reducer performance: reduction ratio, mechanical and thermal ratings, and overhung-load capacity.

Under the second category are those selection factors that are concerned chiefly with the physical configuration of the reducer—for example, shaft orientation, mounting system, cooling methods and other accessory equipment.

Relative rank assigned to these factors will always depend upon the special demands of the application. In almost every situation, they are considered collectively, rather than individually.

Performance Factors: As a major link in a power-transmission system, the speed reducer has one first-order purpose: it permits both prime mover and driven machine to run at their optimum speeds. Ratio desired between these speeds, calculated as the quotient of input and output rpm, provides one of the first guide posts in the reducer selection process.

RATIO VS TYPE: Common ratio ranges associated with the various reducer types, in both single and multiple-stage arrangement, are shown in Fig. 10. In almost every gearing form and ratio, reducers are furnished with mechanical ratings ranging from fractional-power sizes, Fig. 11, to those rated in hundreds of horsepower. Because of this variety of combination in ratio and power, and because there is considerable overlap in ratios provided by all types—particularly in the intermediate ranges—selection of a reducer is seldom resolved on a basis of ratio alone. Efficiency, for example, can be used as another useful criterion for reducer selection.

How simultaneous evaluation of ratio and efficiency can help solve the reducer selection problem is illustrated by a comparison of performance characteristics of, for example, right-angle worm-gear and spiral-bevel reducers.

RATIO VS EFFICIENCY: Because of obvious advantages in compactness, ruggedness and simplicity, the worm-gear reducer is perhaps the most common right-angle drive in current use. But the lower limit set on practical worm-gear ratios (about 3:1 minimum) may not satisfy the application requirements, and efficiency of the worm-gear falls off at higher ratios.

In contrast to the 3:1 minimum ratio of the worm unit, the spiral-bevel reducer, Fig. 12, has a ratio range starting as low as 1:1.

Efficiency comparison for right-angle worm and spiral-bevel reducers is shown in Fig. 13. Up to the 10:1 ratio, efficiency differences between the two types are small. As ratios increase further,

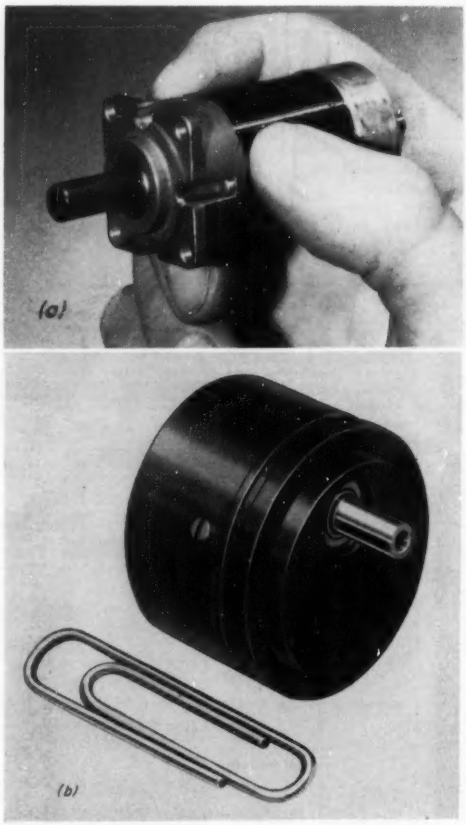
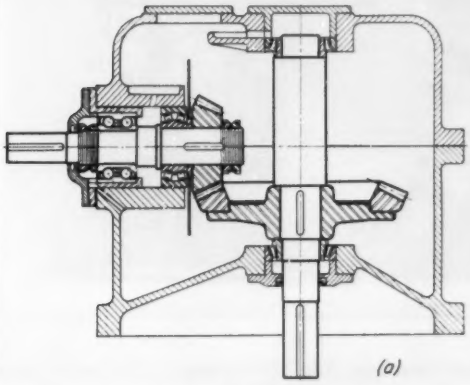
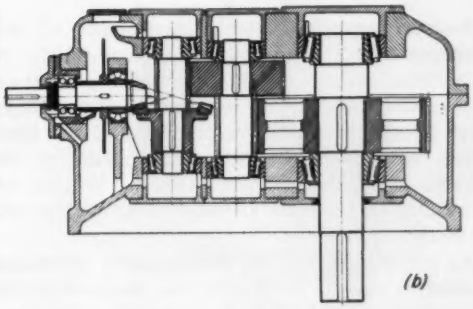


Fig. 11—For instrument and control applications, precision miniature reducers can be specified in a variety of gearing forms. Planetary-gear reducer *a* provides a range of ratios from 18.78:1 to 21,808:1; weight is 2.5 to 8.0 oz, depending upon ratio and mounting style. Servo-motor gearhead *b* employs multiple- stage spur gearing and is rated at 12 to 20 oz-in. torque; moment of inertia at the input shaft is 0.00375 gm-cm^2 maximum.

efficiency of the worm-gear unit drops off quite sharply. At 90:1 ratio, for example, the worm unit dissipates nearly 45 per cent of input power as heat (55 per cent efficiency). At the same ratio, the spiral-bevel reducer wastes only about 5 per cent of input power. Where environmental temperatures are high, low efficiency of the worm-gear unit may lead to the necessity for an auxiliary cooling system to keep operating temperatures within safe limits.



(a) Vertical single-reduction spiral-bevel unit.



(b) Vertical triple-reduction unit (spiral-bevel plus two helical)

Fig. 12—Simple and combined spiral-bevel right-angle reducers. Single-reduction unit *a* provides ratio range from 1:1 to approximately 8:1. Cross-bred gearing arrangement *b* combines spiral-bevel input stage with two helical-gear stages.

Performance comparisons of this kind, pointing in this example to the possible merits of each system in different ratio ranges, are important aids in the reducer selection problem. In general form, efficiency vs ratio characteristics for the spiral-bevel unit, Fig. 13, approximate those for helical and herringbone reducer types. Fig. 3 summarizes the more common efficiency approximations that can be used in preliminary evaluation. In every application, best reducer choice will be one that strikes a balance between first cost, which is a function of reducer type and staging, and operating cost, which is a function of operating efficiency and reducer durability.

OVERHUNG-LOAD CAPACITY: Where coupling of the reducer to prime mover or driven load is direct —say, with either flexible or rigid couplings—reducer overhung-load capacity is of no particular consequence in the selection process. Normal care must naturally be exercised in mounting both coupling and reducer so as to avoid preloading shafts and bearings.

However, where external drives—for example, gears, chains or belts—are employed, first step in evaluation of reducer overhung-load capacity is to compute equivalent overhung load by means of Equation 1. The calculated equivalent load should never exceed the prescribed allowable value for the reducer under consideration. On occasion, allowable overhung load may be found inadequate in a reducer that is entirely satisfactory on all other counts. In such event, several courses of action are open: (1) increase the pitch radius of the overhung drive member; (2) select a larger size reducer; (3) select a reducer of the same rating but with higher than standard overhung-load capacity; or (4) use a special extended shaft with an outboard bearing.

Chief design difference between standard and heavy overhung-load reducers, Fig. 14, is in use of heavy housings, large-diameter shafts and high-capacity bearings in the heavy-duty units. Out-

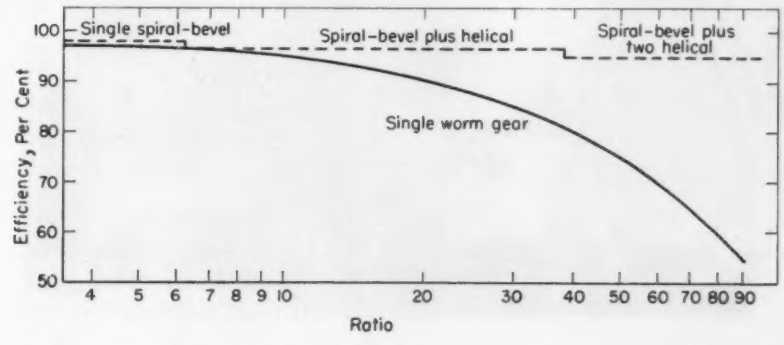


Fig. 13 — Efficiency comparison for single-worm and spiral-bevel reducers.

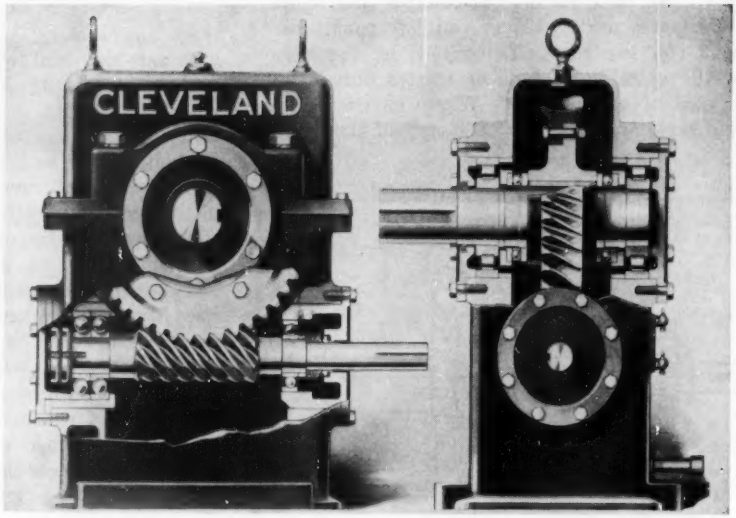


Fig. 14 — Worm-gear reducer adapted for severe overhung-load application. Overhung-load capacity on the low-speed shaft is limited only by shaft strength.

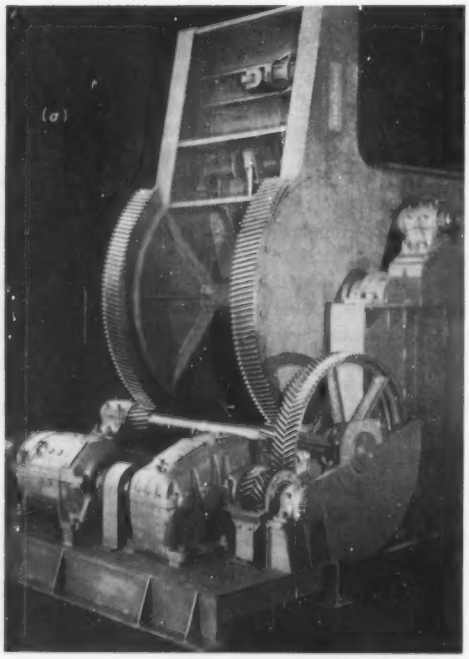
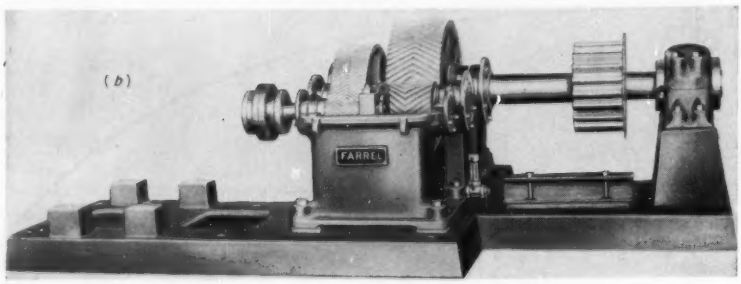


Fig. 15 — Extended shafts and outboard bearings are used when overhung shaft loads exceed rated reducer capacity. Installation *a* is for hot-strip coil conveyor. Double-reduction herringbone reducer with bedplate-mounted outboard bearing is shown in *b*.



board bearings, Fig. 15, are supplied by many manufacturers as accessories to their standard line of reducers.

Nonperformance Factors: Separation of performance and nonperformance factors in the reducer selection process is not absolutely clear-cut in all categories. Shaft orientation, for example, must obviously satisfy requirements of the application, with space limitations and mounting convenience being the principal criteria. Yet, for any given gearing type, not all ratios are available with all shaft orientations.

As a case in point, the parallel-shaft worm-gear reducer is usually built with the double-reduction stage arrangement, Fig. 16. Lower limit on practical ratios is therefore about 15:1. Should a lower ratio be required in a parallel-shaft application, another gearing form may satisfy ratio requirements. It is also possible that cost or performance advantages can be realized if re-evaluation of the application will permit substitution of a right-angle reducer for the originally planned parallel-shaft unit. As a general rule, reducer selection should be considered an integral part of the overall design

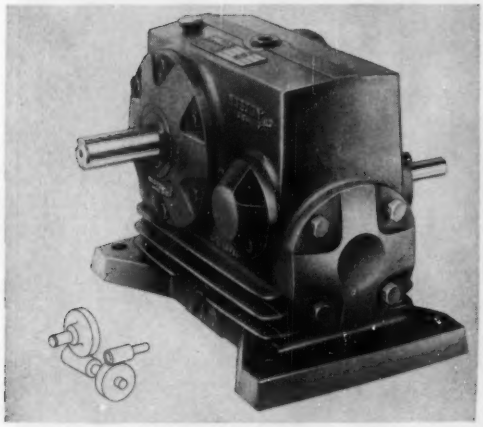


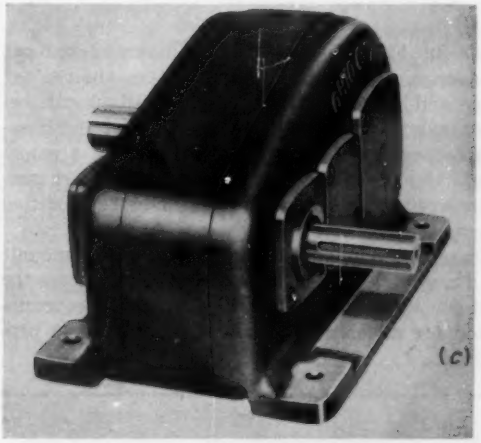
Fig. 16 — Parallel-shaft double-reduction worm-gear reducer.

problem. In few cases will an effective installation result if the reducer is simply "tacked on" after design of the driven machine has reached final form. Rational selection of the best reducer mounting style, for example, deserves careful consideration at an early point in the design study.

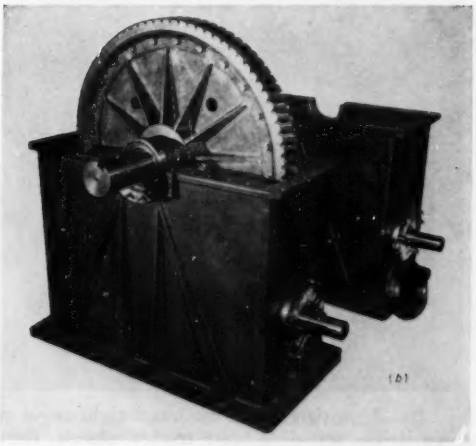
MOUNTING STYLE: Because of the wide variety available, reducer mounting styles seldom impose a restriction on the designer's choice of reducer location or position. Following usual convention, reducer mountings are grouped here under two general categories: (1) conventional types, wherein the reducer is either foot-mounted or supported by an integral base or flange; and (2) shaft-mounted types, wherein the reducer is supported directly on the driven-load shaft.

Representative conventional-style mountings are

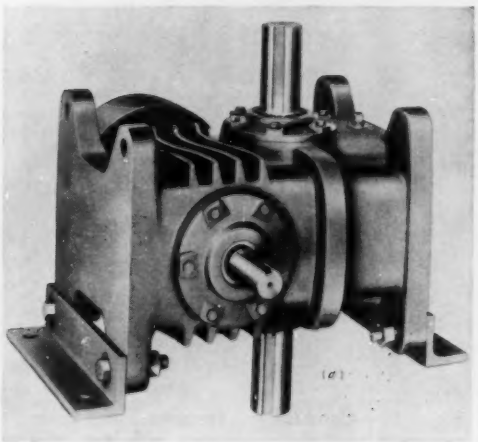
(a) Flange-mounted inline differential reducer.



(c) Foot-mounted helical-gear parallel-offset reducer.



(b) Base-mounted worm-gear reducer, welded-steel housing.



(d) Base-mounted worm-gear right-angle reducer.

Fig. 17—Conventional reducer mounting styles.

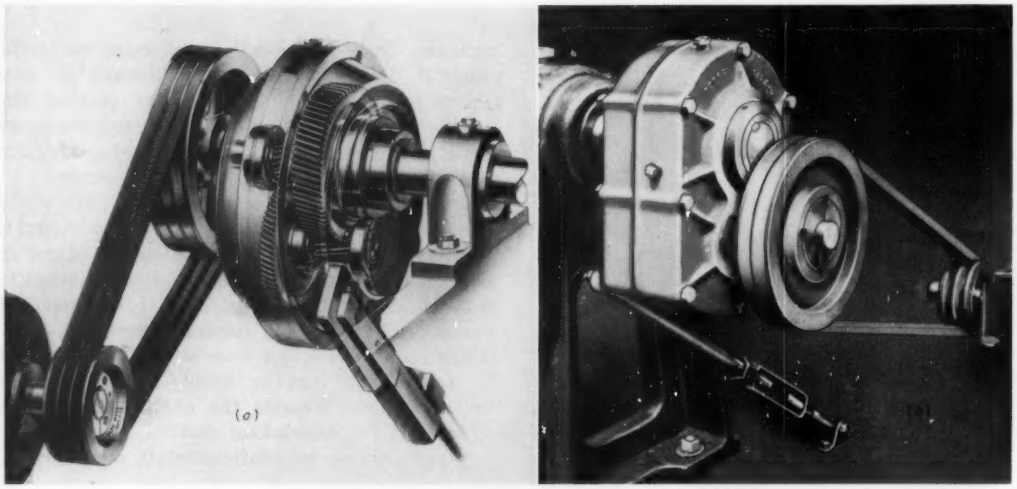


Fig. 18—Shaft-mounted speed reducers illustrating in-line type *a* and offset-shaft type *b*.

shown in Fig. 17. The flange-mounted reducer provides a more compact installation than other types and assures permanence of alignment between reducer and driven machine. Foot and base-mounted units, on the other hand, allow a somewhat wider choice of reducer position, and are generally used where reducer ratio must be modified by external belt or chain drives.

The shaft-mounted reducer, designed for mounting directly on the driven-load shaft, eliminates the need for reducer foundations, Fig. 18. Accommodation for different driven-shaft diameters is provided by a bushing that extends through the reducer final-drive sleeve. The reducer is anchored against rotation by a variable-length torque arm which, in the offset-shaft type, also serves as a belt-tension adjustment. In application, shaft-mounted reducers are usually combined with external speed-reducing drive systems, thereby expanding the ratio range and the number of intermediate ratios attainable.

Combining the features of both conventional and shaft-mounted reducers, worm-gear units of the type illustrated in Fig. 19 are available.

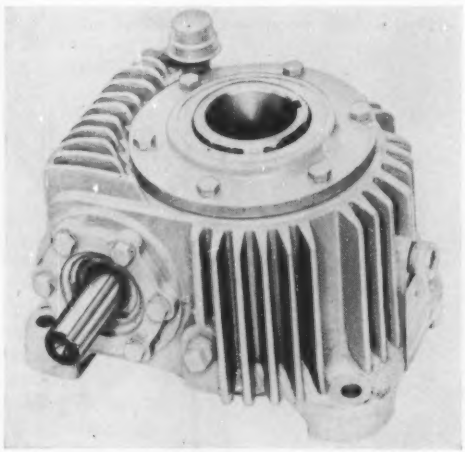


Fig. 19—Combining features of base-mounted and shaft-mounted reducers, this right-angle worm-gear reducer eliminates need for flexible or rigid couplings between reducer and driven load.

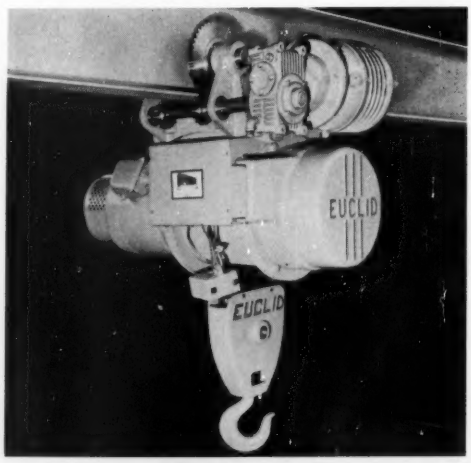


Fig. 20—Motorized shaft-mounted right-angle reducer drives traveling-hoist trolley wheels. Drive is from a 3-hp, 1800-rpm motor through a double-enveloping worm-gear unit mounted on a shaft journaled in the hoist frame.

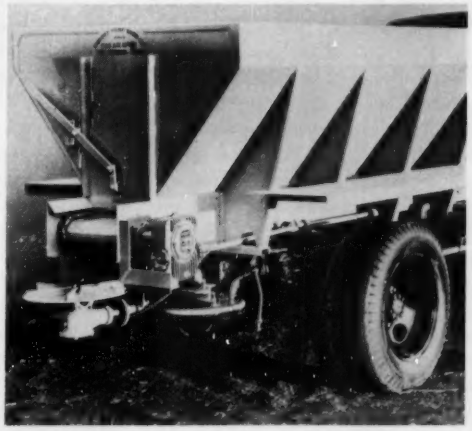


Fig. 21—Standard right-angle worm-gear reducer transmits power from the power-take-off shaft in this lime spreader to the rotating distributing fan.

Mounted directly on the driven shaft without intermediate couplings, such reducers are base-supported, and therefore no torque arm is necessary.

REDUCER WEIGHT: Although normally secondary to considerations of durability or economy in the more conventional applications, reducer weight (or size) may present a selection problem in mobile or portable installations, Figs. 20 and 21. A rough comparison of the weights of reducers incorporating different gearing forms can usually be based upon the stated catalog weights. Substitution of a reducer of different shaft orientation may lead to substantial weight reduction. Where a reducer seems ideally adapted to the demands of an application except for its weight, substitution of an air-cooled model of the same reducer type, or use of air-cooling accessories, may offer appreciable improvements in reducer power-to-weight ratios.

COOLING AUXILIARIES: In a reducer that is completely satisfactory from a mechanical rating standpoint, thermal rating may, for some reason, be too low. This possibility exists wherever substantial amounts of power must be transmitted at relatively high reducer input speeds, or wherever ambient air temperatures exceed the specified limit. The situation may also be anticipated where space restrictions may interfere with the normal convective cooling-air flow over the reducer housing.

In such cases, a possible remedy lies in the substitution of a reducer that is a size or two larger than mechanical rating requirements of the application alone dictate. However, since the principal hazard of high reducer operating temperatures springs from poor lubrication of gearing, oil-bath water-cooling coils, supplied as optional equipment with many reducer types, may reduce oil temperatures to acceptable levels. Reducers adapted for auxiliary cooling equipment are usually provided with drilled and tapped bosses, which make installation of cooling coils a relatively simple matter.

Where a cooling-water supply is not available, or where the reducer type under initial consideration makes no provision for cooling coils, air-cooled

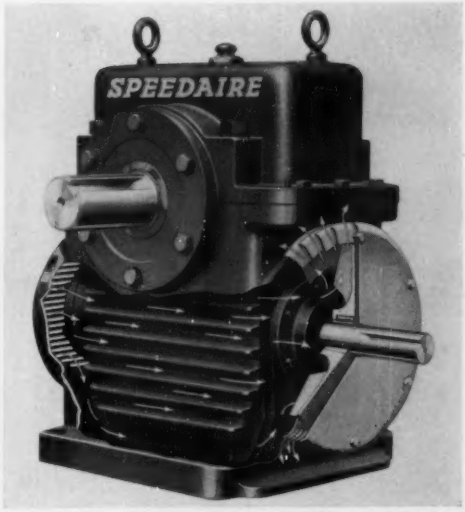


Fig. 22—Fan-cooled worm-gear reducer. High air velocities induced along reducer housing walls increase heat-dissipation rates as much as 100 per cent over convection-cooled models.

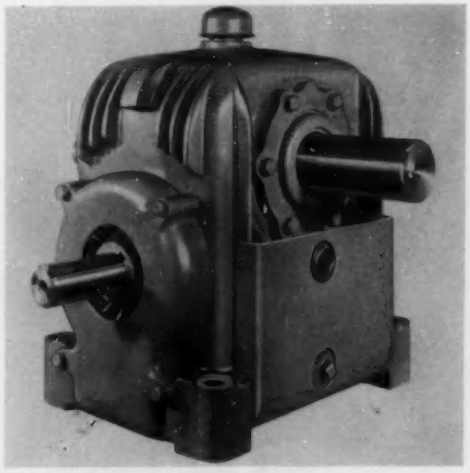


Fig. 23—Conversion of convection-cooled reducers to forced-air cooling is often quite simple. Addition of impeller and air-flow control shields raises the thermal rating of this right-angle worm-gear unit without appreciably increasing physical dimensions.

reducers offer a solution to the thermal rating problem, Fig. 22. Because of the forced-air scrubbing of housing exteriors, such units have much higher thermal ratings than comparable convection-cooled models. Load-carrying capacity is therefore appreciably higher than for standard reducers of equal center-distance dimensions.

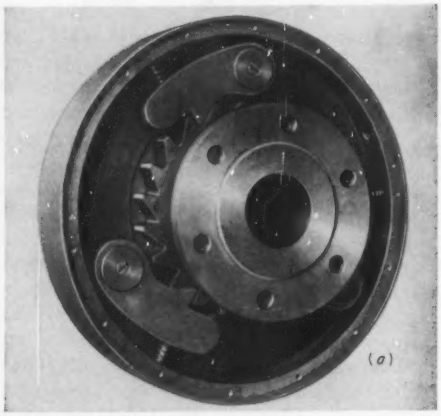
In some reducer models, either fan or water-cooling auxiliaries are offered as optional equipment, Fig. 23. Conversion of the basic reducer to the fan-cooled version is quite simple, requiring only the installation of a standard impeller on the worm shaft and the addition of air-flow control shields to the reducer housing. Neither part significantly increases overall reducer dimensions.

Use of fan-cooled reducers, or the addition of air-cooling accessories to standard models, will often provide the answer to low thermal-rating difficulties. However, recommendations on low input-speed limits should always be observed. Increased thermal ratings certified for these units presume operation at input speeds high enough for effective air circulation by the cooling fan.

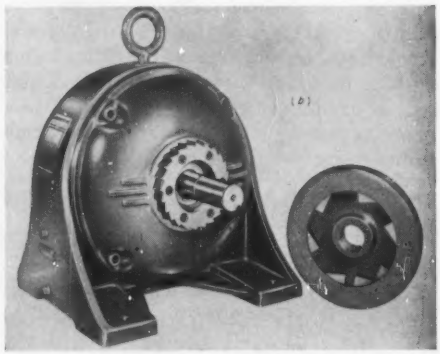
BACKSTOPS: Reverse rotation of a reducer, caused by action of the load on the reducer output shaft, is usually undesirable. When power fails on a loaded, reducer-driven conveyor, for example, weight of the load may drive the reducer in reverse, spilling the load and damaging conveyor or reducer components. Although some gearing forms—high-ratio worm units, for example—are sometimes considered to be self-locking, the AGMA has this to say about irreversibility:

> For complete assurance of irreversibility, it is advisable to resort to use of a brake, rather than to rely on the self-locking characteristics of gearing.

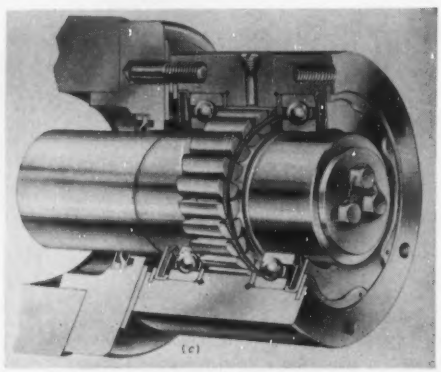
To prevent reverse rotation, integrally or separately mounted backstops are furnished as accessory equipment by practically every reducer manufacturer. Operating on either the sprag-clutch principle or as a pawl-ratchet device, Fig. 24, backstops are usually fully automatic in ac-



(a) Pawl-ratchet unit, a combination backstop and flexible coupling.



(b) Multiple pawl and ratchet unit, designed for integral mounting with the reducer.



(c) Integrally mounted sprag-clutch backstop for minimum backlash.

Fig. 24—Typical reverse-rotation backstops.

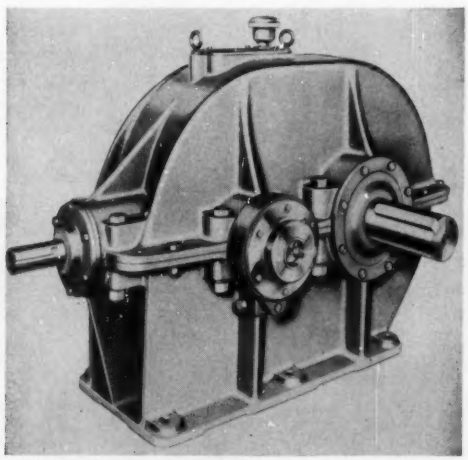


Fig. 25—Typical sprag-clutch backstop installation. Backstops can be mounted on either side of a single-stage reducer, or on an intermediate shaft extension in multistage units.

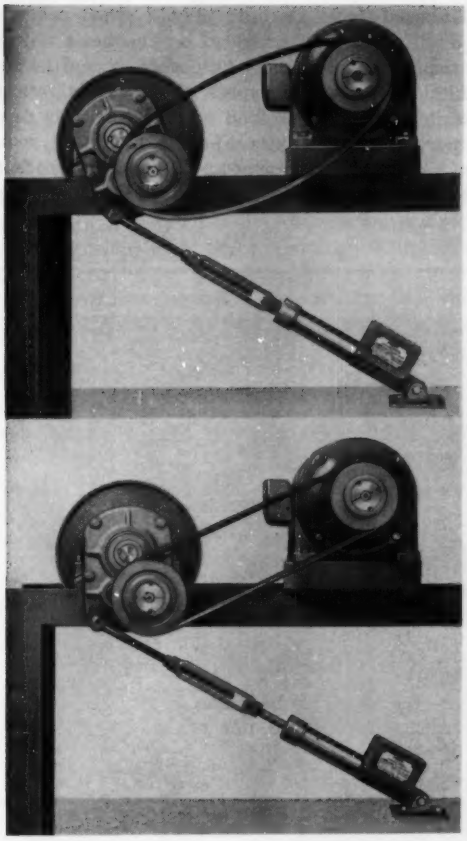


Fig. 26—Torque-arm overload release for shaft-mounted reducer. When actuated, overload device simultaneously releases belt tension and signals presence of overload condition.

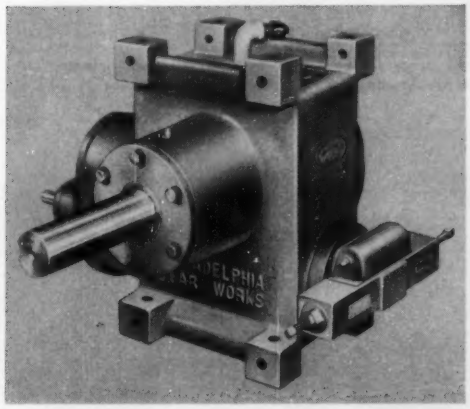


Fig. 27—Torque control in this right-angle reducer, combining helical-gear input and worm-gear output stages, is provided by a torque-sensing snap-action switch on the worm-wheel (slow-speed) shaft.

tion. Best mounting position for the backstop depends upon the nature of the application. It can be on the high-speed shaft projection, or on an intermediate-stage shaft extension in a multistage reducer, Fig. 25.

TORQUE LIMITERS: Reaction torque in shaft-mounted reducers is balanced by the reducer torque arm. For preventing overload damage in such installations, a torque-arm overload release, Fig. 26, is available. Excessive force in the torque arm, caused by reducer overload, translates a calibrated spring-loaded piston in the overload release arm, loosening the drive belt and simultaneously cutting off power to the motor. The release point can be adjusted to suit load demands of the application.

SHEAR COUPLINGS: With large reduction ratios, the conventional reducer is quite easily damaged by an oversized drive motor. To control excess torque that may be developed by heavy overloads, shear-pin couplings can often be employed. Provision of a shear-pin coupling, however, is no guarantee that the reducer will not be overloaded continuously, with consequent reduction in service life. This is because shear pins must be sized to withstand the starting capacity of the reducer, and therefore will fail only under extreme, not moderately heavy overload conditions.

Torque control in conventionally mounted reducers can be provided by accessories like that illustrated in Fig. 27. In this helical-worm-gear unit, excess torque in the worm-gear (slow-speed) shaft actuates a snap-action switch. Through the motor control circuit, the switch cuts current to the reducer drive motor. The overload release point can be adjusted to suit the demands of the application, and no resetting of the mechanism is required after the overload has been removed.

Reducer Installation

Life and efficiency of a properly rated speed reducer depend, in a large measure, upon the rigidity and alignment of its mounting. Misaligned shafts impose abnormal stresses on reducer bearings and couplings, leading to excessive wear and early failure. Flexibility in the mounting assembly will permit component vibration, which also results in bearing and gear wear, as well as increased operating noise levels.

Unless reducer and drive motor are mounted directly on the driven machine—as is possible with flange or shaft-mounted reducers—it is usually desirable to provide cast or welded bedplates backed up by a firm foundation as support for both reducer and motor. Standardized cast-iron or welded-steel bedplates are offered by most speed-reducer manufacturers, Fig. 28. The superior stiffness of steel, section for section, as compared to cast iron makes the welded-steel bedplate a better choice for overhead installation, or wherever the

bedplate cannot be supported over its full length.

Speed reducers are fabricated with certain specified tolerances between shaft centers and base. Since such tolerances must be anticipated in the selection or design of a reducer mounting, usual practice is to provide for final positioning of the unit by means of shims. It should be noted that catalog reducer dimensions are presented for preliminary evaluation and calculation only. Design and construction of the mounting system should always be based on certified reducer prints.

External-Drive Layout: Should speed reduction in addition to that provided by the basic reducer be required, it is usually advisable to confine such reduction to the slow-speed shaft. This practice diminishes the torque load on the reducer in direct proportion to the external-drive ratio. If reduction between prime mover and reducer is necessary, the ratio should be kept as small as possible. Good

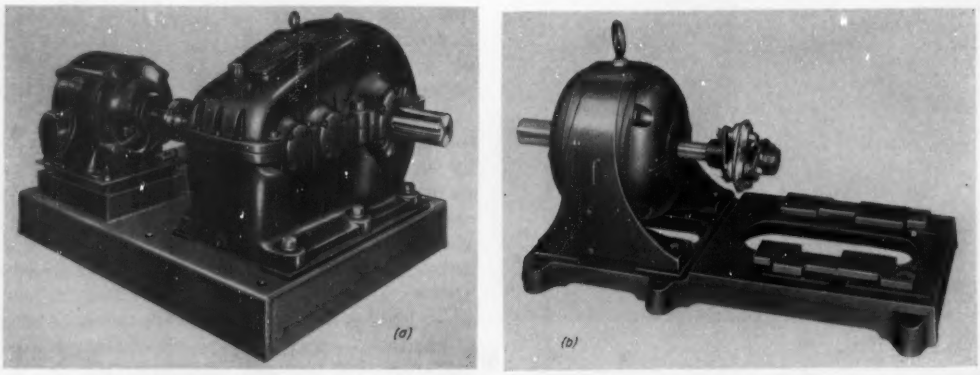
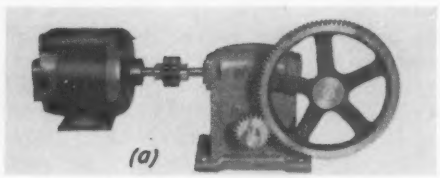
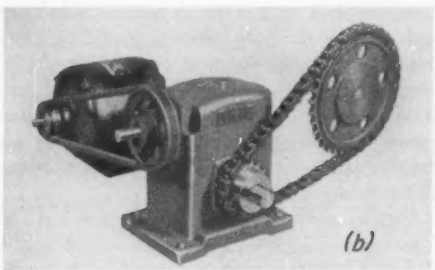


Fig. 28—Typical welded-steel *a* and cast-iron *b* reducer bedplates. Bases are generally supplied as standard accessories to a line of packaged reducers.



(a) Good practice: Reducer is driven directly through flexible coupling; no overhung load is imposed on reducer input shaft. Additional reduction is obtained through spur gears mounted close to housing on the output shaft.

(c) Bad practice: External reductions in good balance, but drives are mounted too far from the reducer housing.



(b) Good practice: V-belt drive from motor to reducer, chain drive from reducer output shaft. Ratios of external drives are balanced, with larger ratio on output shaft. Drives mounted close to housing eliminate excessive bending loads.

(d) Bad practice: External reduction drives correctly mounted, but ratio is out of balance. Large reduction between motor and reducer subjects reducer to possible overload.

Fig. 29—Good and bad practices in speed-reducer installation where external speed reduction is employed.

and bad practices in speed-reducer component location are shown in Fig. 29.

Under certain application conditions, economies can be effected if external drive means are used to decrease required speed-reducer ratio. Assume, for example, that a reducer installation with a total ratio of 75:1 is needed. This ratio can be delivered by a single-stage worm-gear unit, although efficiency may be quite low and the reducer may be relatively bulky. A more economical combination may be one employing a single-stage worm unit of say 25:1 ratio, with the remainder of the speed reduction (3:1) being delivered by a chain, belt or spur-gear drive system between the low-speed shaft and the driven load.

Gearmotors and Motorized Reducers

Compactness, rigidity of component alignment and single-source responsibility for performance matching of the gearbox-motor combination are advantages that have led to widespread application of gearmotors and motorized reducers. Variety in gearmotor shaft orientation, output speed and power rating matches that of the separate reducer, and imposes little restriction on potential areas of application.

Gearmotors are simply parallel or right-angle gearboxes combined with integral or flange-mounted motors, Fig. 30. Distinguished from the gearmotor—in physical appearance, if not by performance—is the all-motor or motorized reducer, Fig. 31. Incorporating a unified mounting base for both motor and gearbox, the all-motor reducer allows a somewhat wider choice of drive motor. This arrangement is particularly advantageous where an entire plant is standardized on a particular motor type for interchangeability, or where existing motors must be utilized. Where the motor-gearbox combination is factory specified (or approved), the selection process for the all-motor reducer parallels that for the pure gearmotor.

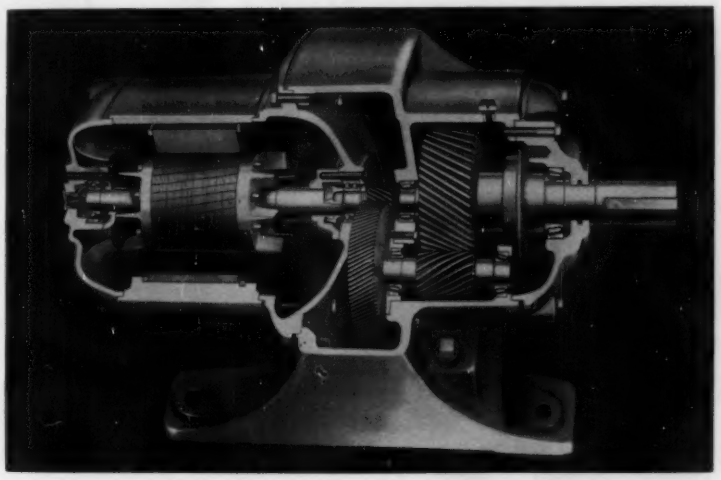


Fig. 30—Parallel-shaft gearmotor. Reducer housing encloses reducer gearing and holds flange-mounted motor in permanent alignment.

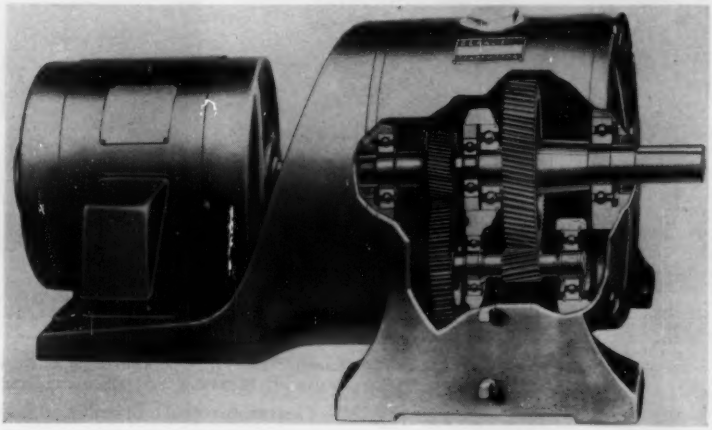
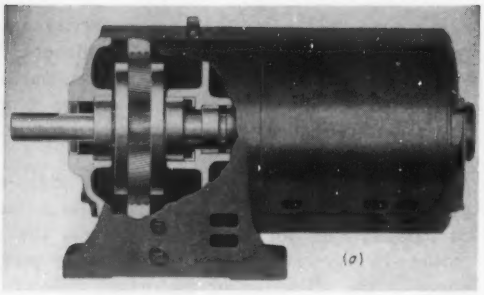
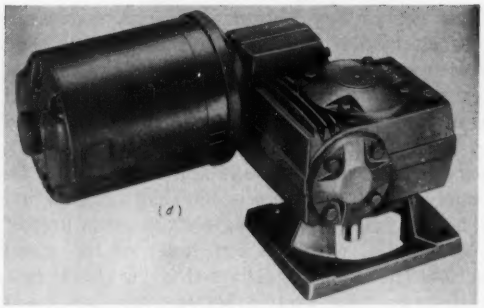


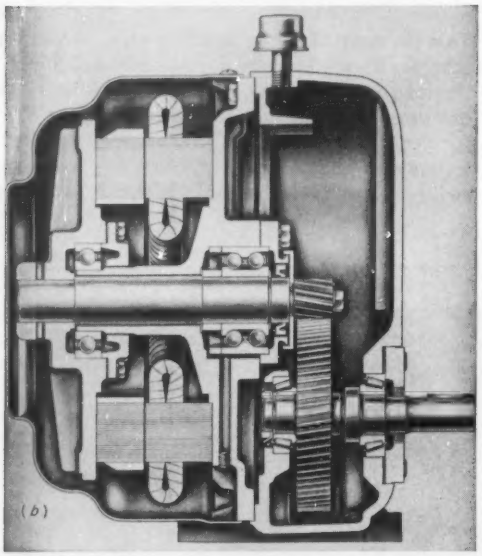
Fig. 31 — All-motor motorized reducer with shovel-base mounting for NEMA foot-type motors. Design permits introduction of flexible, rigid or fluid couplings between motor and reducer sections.



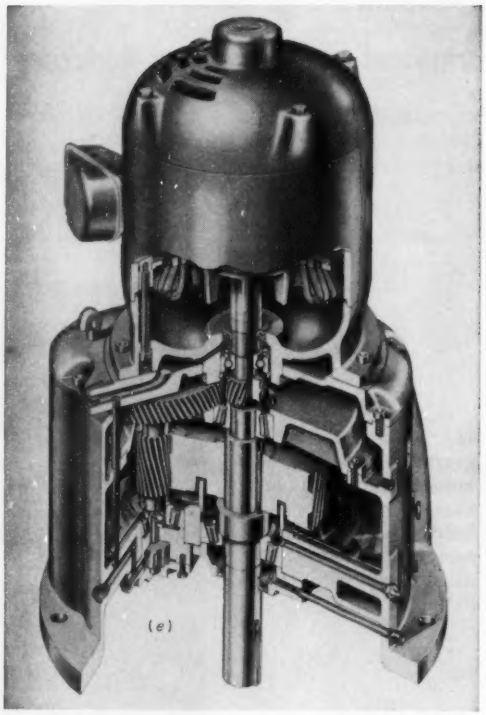
(a) Parallel-concentric (inline) planetary unit.



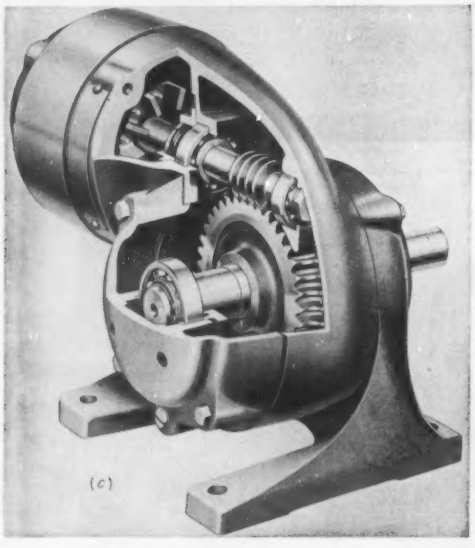
(d) Right-angle double-worm unit (vertical).



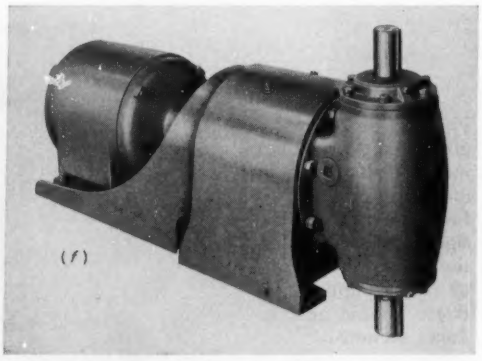
(b) Parallel-offset single-stage helical unit with axial air gap motor.



(e) Parallel-shaft two-stage unit (vertical).



(c) Right-angle single-worm unit (horizontal).

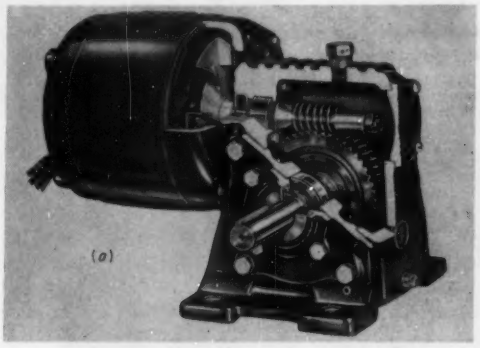


(f) Right-angle all-motor unit, double shaft extensions.

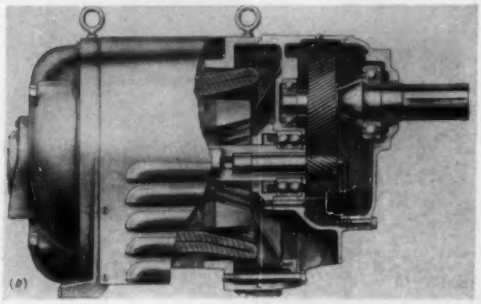
Fig. 32—Gearmotor shaft orientation.

Gearmotor Classification: Principal categories of gearmotor classification group these units according to shaft orientation, gearing type and arrangement, and motor type and enclosure. In the basic gearmotor, the user is often provided with optional mounting styles, or with a choice of reducer end-bell positions. Illustrations of the principal gearmotor and motorized reducer configurations are given in the following sections.

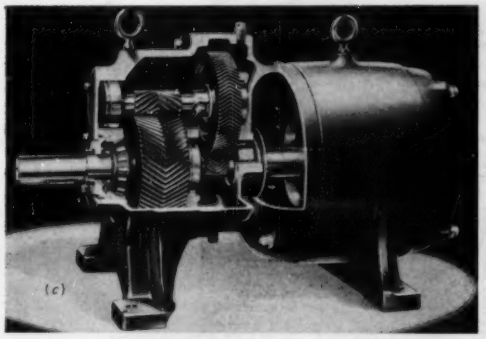
SHAFT ORIENTATION: Paralleling conventional practice for separate reducers, gearmotor shaft



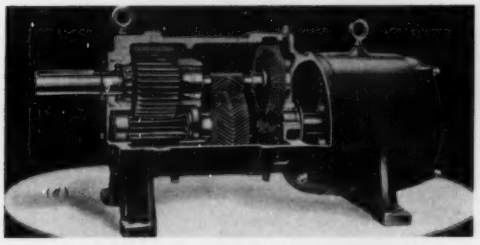
(a) Right-angle worm-gear unit with open motor frame.



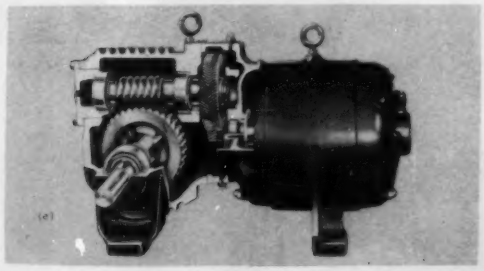
(b) Single-reduction helical-gear unit with standard enclosure.



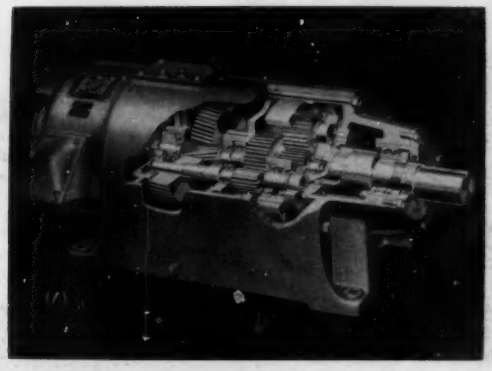
(c) Double-reduction herringbone-gear unit.



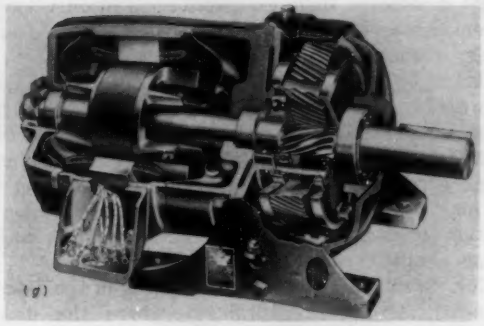
(d) Triple-reduction parallel-shaft unit combining first and second-stage herringbone gearing with spur-gear final stage.



(e) Double-reduction herringbone-worm-gear unit.

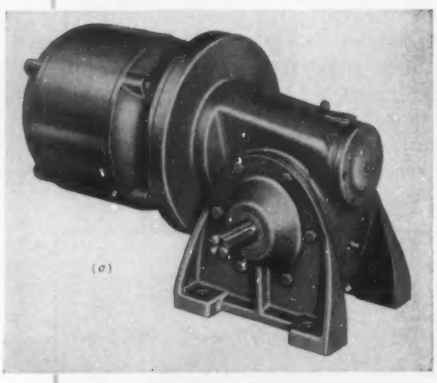


(f) Triple-reduction unit combining dual-countershaft helical-gear first stage, spur-gear second stage and planetary-gear final stage.

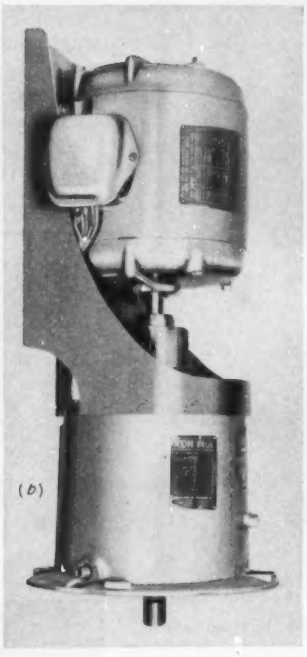


(g) Concentric-shaft planetary unit.

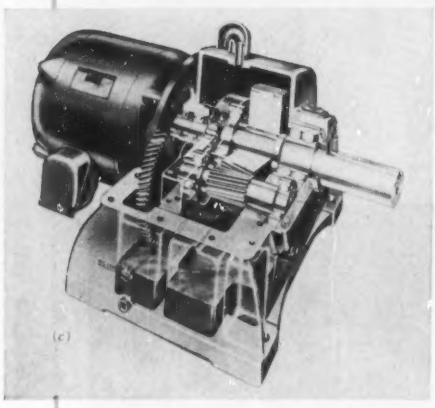
Fig. 33 — Packaged gearmotors, showing extreme variety in gearing type and stage arrangement.



(a) Flange-mounted right-angle gearmotor.



(b) Flange-mounted vertical all-motor unit.



(c) Base-mounted double-reduction helical unit with split-case construction.

(d) Flange-mounted double-reduction gearmotor with explosion-proof motor.

Fig. 34—Basic gearmotor mounting arrangements.

orientation is described as parallel (concentric or offset), right-angle, horizontal or vertical, Fig. 32. Where use is feasible, the parallel-shaft gearmotor will probably be preferred to the right-angle type because it offers higher efficiency and, therefore, lower operating costs. Nevertheless, the right-angle gearmotor finds extensive application where mounting-space limitations take precedence over minor reductions in gearbox efficiency.

GEARING TYPE AND ARRANGEMENT: As for separate speed reducers, gearmotor gearing can be spur, helical, herringbone, worm or combinations of these basic forms. Output speed will generally determine stage arrangement of the gearing, whether single or multiple-stage, planetary or differential. Illustration of the variety of gearmotor gearing and stage arrangement is given in Fig. 33.

Compared to its first-ranking status in the separate-reducer selection problem—where the user normally solves the motor-reducer performance-matching problem—specification of gearing type for the packaged gearmotor becomes more nearly the option of the manufacturer. Advantages of such single-source design responsibility are obvious, since the user can reasonably assume that

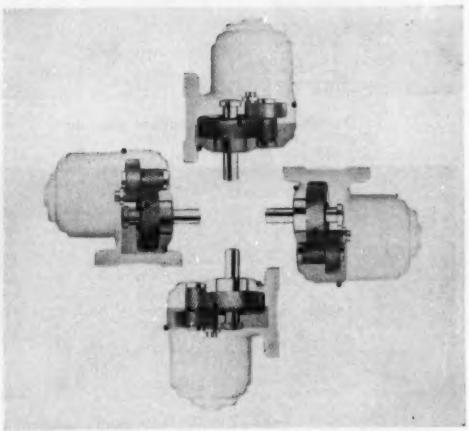


Fig. 35—Many gearmotors can be mounted in positions other than horizontal, although oil fill, check and drain plugs may need to be relocated. This particular model permits all-position mounting without modification.

the gearmotor gearing has been properly selected for speeds and power levels for which the unit is rated. Furthermore, because the motor is sized with a continuous rating equal to the mean steady-state power demands of the expected load, there is little chance that the gearbox section will be overpowered. Such considerations do not, however, completely eliminate possibilities of reduced service life or damage to the gearmotor due to misapplication.

In every gearmotor, motor torque in excess of the continuous value is provided to break away and accelerate load inertia, overcome gearbox friction and handle load pulsations that may occur during operation. Continued overloading, or exposure to operating shock more severe than the allowable value will substantially shorten service life of the unit.

Except in their effect on operating costs, efficiencies of neither motor nor reducer are significant factors in calculations leading to specification of gearmotor size required. These efficiencies —and the associated losses they represent—have been taken into account in the gearmotor manufacturer's listing of output-shaft power and torque. Nevertheless, the user is still required to estimate correctly both load-characteristic and duty cycle of the application, and to incorporate resulting serv-

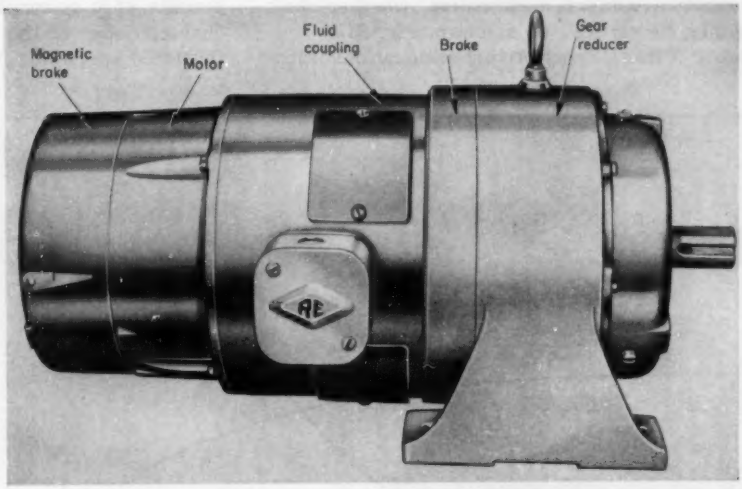


Fig. 36 — Double-reduction gearmotor with fluid coupling between motor and gearbox. Magnetic brake on motor end of assembly smoothly decelerates load without shock. Brake between fluid coupling and gearbox provides positive locking of load.

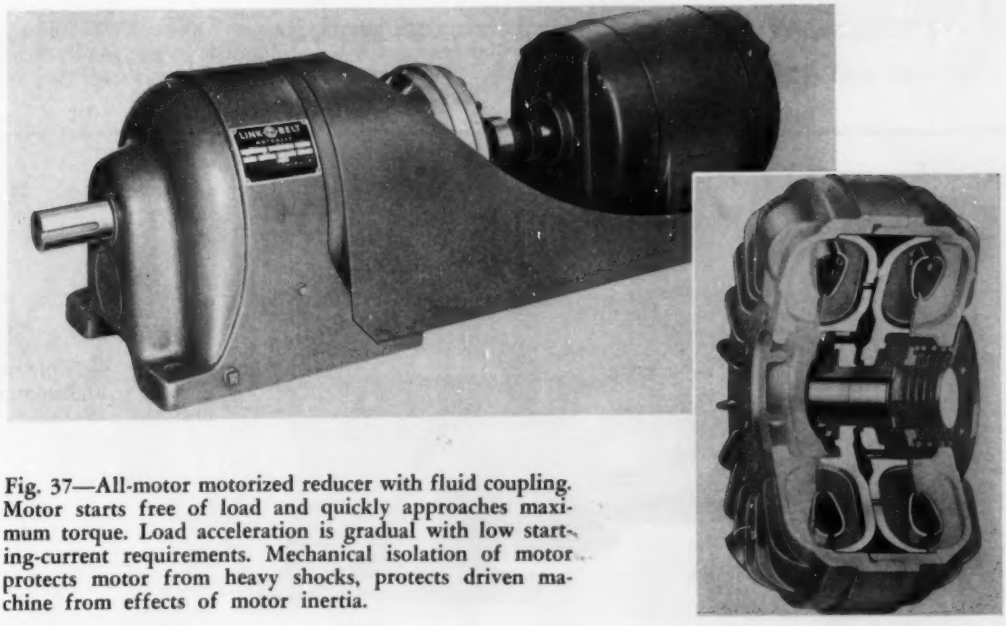


Fig. 37—All-motor motorized reducer with fluid coupling. Motor starts free of load and quickly approaches maximum torque. Load acceleration is gradual with low starting-current requirements. Mechanical isolation of motor protects motor from heavy shocks, protects driven machine from effects of motor inertia.

ice factors in the gearmotor performance specifications.

The foregoing discussion applies generally to both the gearmotor and to the motorized or all-motor reducer, especially where performance matching of motor to gearbox has been carried out by the manufacturer. However, where the factory-recommended motor in an all-motor reducer is to be replaced by one of different characteristics or of higher rating, the installation must be carefully checked to ensure that the gearbox will not be overpowered.

MOUNTING STYLES: Gearmotor mountings are normally classified as foot or base-mounted, face or flange-mounted. Illustration of these basic forms is given in Fig. 34. Although minor change in breather or lubrication fittings may often be required, gearmotors can sometimes be mounted in any position without modification, whether shaft horizontal or vertical, up or down, Fig. 35.

MOTOR TYPES: Descriptive classification of the motor end of a gearmotor combination usually specifies the following: (1) motor type, (2) power, (3) speed, (4) voltage, (5) phase, (6) frequency, (7) enclosure, (8) electrical and mechanical accessories.

Because of the breadth of the subject, no attempt is made in this article to present the factors involved in selecting the best motor type for a gearmotor application. A detailed survey of mechanical and electrical features of standard and special-purpose motors, all generally available in packaged gearmotors, is presented in Reference 9.

ACCESSORIES AND SPECIAL DESIGNS: Performance characteristics of standard gearmotors can be expanded to suit wider fields of application by the use of standard accessories.

Fluid couplings, for example, often used to transfer power between the motor and gearbox components of a gearmotor, modify the torque-speed characteristics of the basic motor. Such couplings, furnished as catalog items, are either incorporated

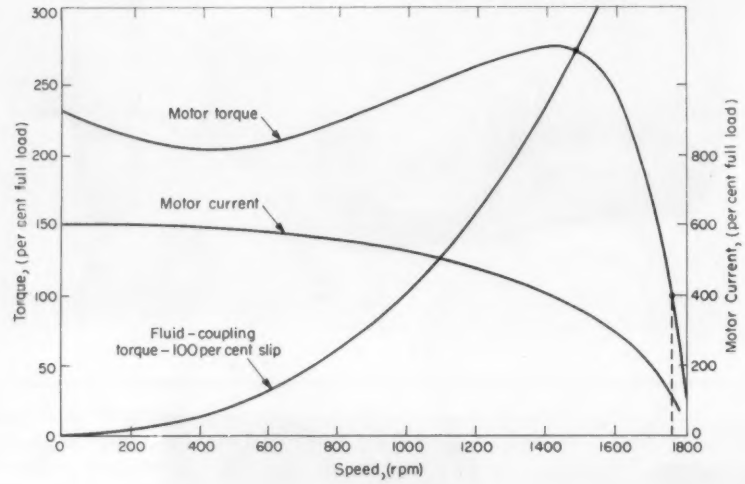


Fig. 38—Performance characteristics of typical 1750-rpm squirrel-cage motor and fluid coupling.

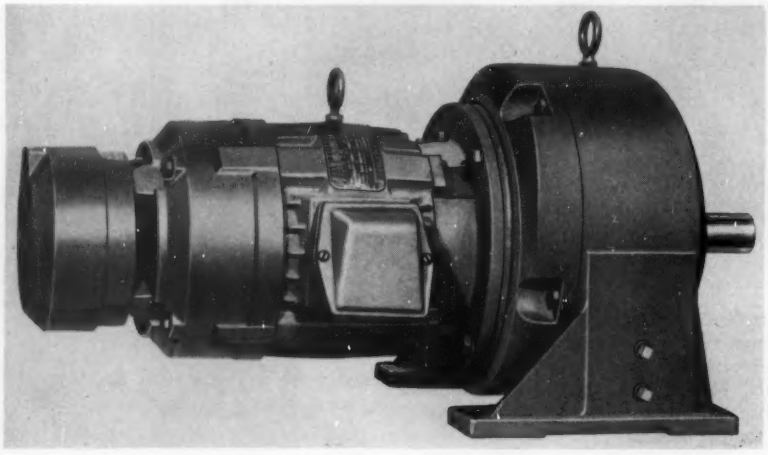


Fig. 39 — Triple-reduction ac brakemotor unit.

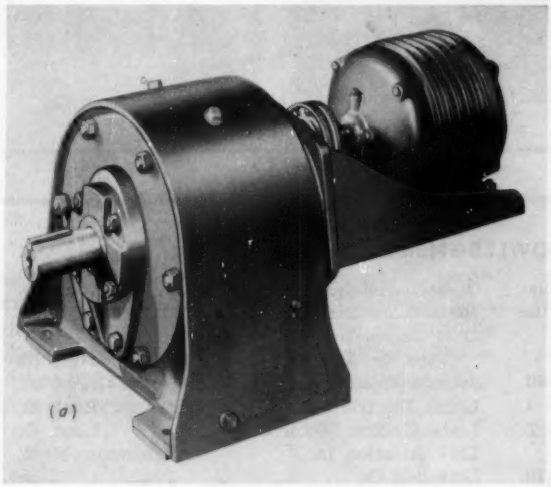
in the gearmotor design, Fig. 36, or are supplied as auxiliary equipment that can be added.

Performance advantages offered by such an installation are: (1) reduction of starting overloads, (2) smooth acceleration of the load, and (3) absorption of operating shocks. Performance of a typical squirrel-cage motor driving through a fluid coupling is illustrated in Fig. 38. Because the motor starts at essentially no-load condition, starting currents are substantially reduced, and a smaller motor than might normally be required in a fixed-coupling gearmotor can be specified.

Magnetic brakes, often in combination with fluid couplings, are also available as integral or separately mounted gearmotor accessories. The arrangement in Fig. 36, incorporating one brake on the motor end of the assembly and another between the fluid coupling and the gearbox, provides smooth deceleration of the load inertia through the fluid coupling, plus positive locking of the load where desired. Fig. 39 illustrates an integral-brake unit without the fluid-coupling.

Normally, when overhung loads exceed the catalog rating for a gearmotor that is otherwise satisfactory, the next larger size can be specified. Special extended-bearing gearmotors have been made, however, as shown in Fig. 40.

Representative of the variety of nonstandard gearmotor types that have been built are the multiple-shaft units shown in Fig. 41. In Fig. 42, a



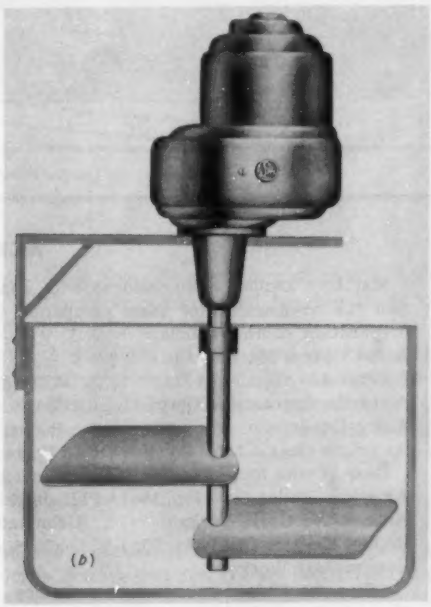
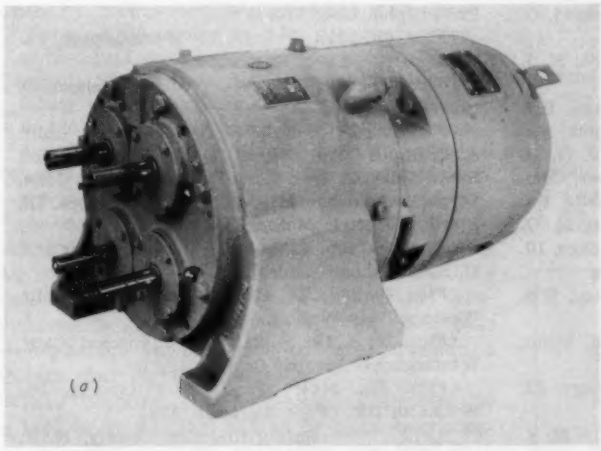


Fig. 40—Extended-bearing gearmotors for heavy overhung loads. All-motor unit *a* has steel housing. Unit *b* is for agitator application.



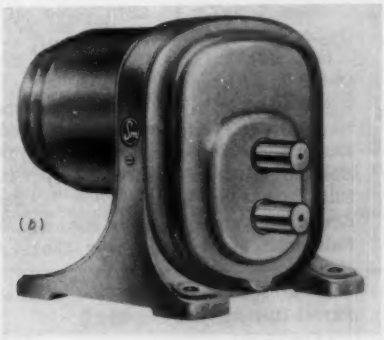


Fig. 41 — Multiple-shaft gearmotors. Four-shaft unit *a* is custom-built pump drive unit. Two-shaft unit *b* may be offered as standard item.

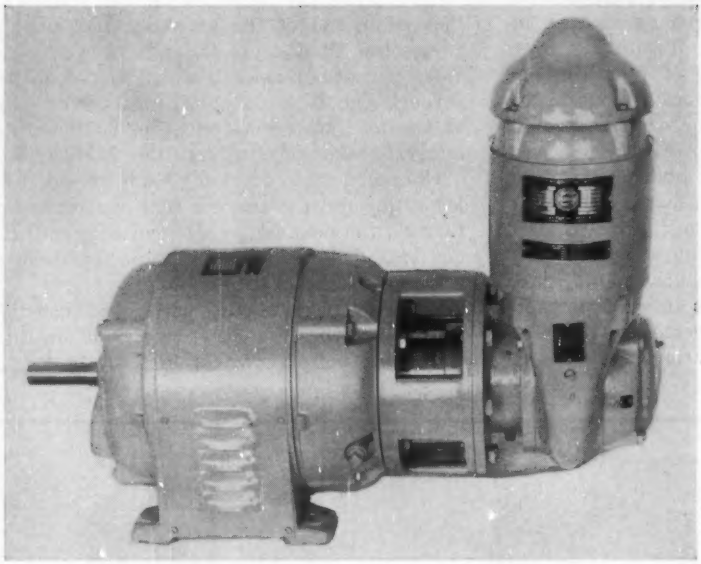


Fig. 42 — Multimotor packaged drive assembly incorporating 1750-rpm motor coupled through overrunning clutch to right-angle, 100-rpm gearmotor.

ACKNOWLEDGMENT

MACHINE DESIGN acknowledges with appreciation the co-operation of these companies in the preparation of this article:

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American Gear & Mfg. Co., Sub. Brad Foote Gear Works Inc. (*Figs.* 4*c*, 5*d*) ... Lemont, Ill.
American Pulley Co. (*Fig.* 18*a*) . Philadelphia, Pa.
Automotive Gear Works ..... Richmond, Ind.
Bodine Electric Co. (*Fig.* 33*a*) ..... Chicago, Ill.
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Elliott Co. (*Fig.* 34*a*) ..... Jeannette, Pa.
Euclid Universal Machine Inc. .... Wickliffe, O.
Fairbanks, Morse & Co. (*Fig.* 32*b*) . Chicago, Ill.
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Ohio Gear Co. (*Figs.* 4*d*, 17*c*, 29) . Cleveland, O.
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Philadelphia Gear Works (*Figs.* 4*b*, 27) ..... Philadelphia, Pa.
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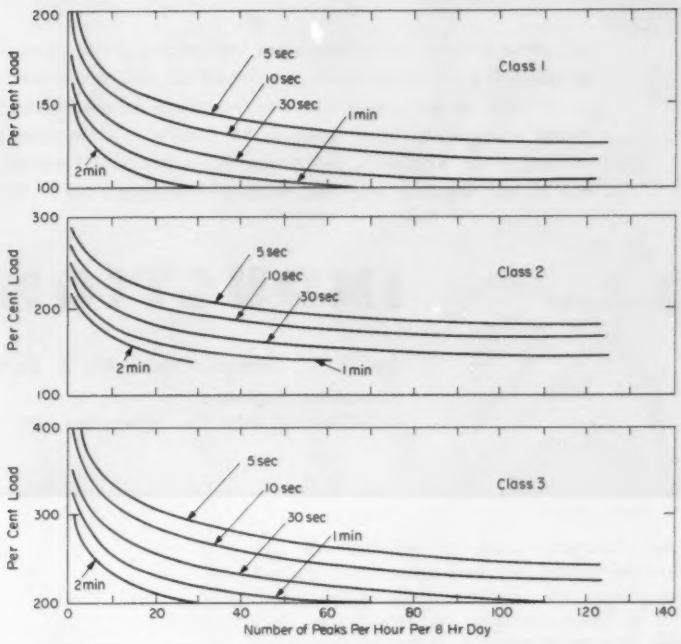


Fig. 43—Variation of allowable intensity of shock with frequency and duration of peak loads.

multimotor packaged reducer is illustrated, incorporating a horizontal motor and a flange-mounted, right-angle gearmotor coupled by an overrunning clutch. This combination provides either 1750 or 100 rpm at the output shaft, depending upon which motor is driving the assembly.

Gearmotor Selection Factors

As in selection of a separate speed reducer, frequency and severity of shock and duty cycle modify steady-state power requirements of the gearmotor application. To assist the user to evaluate driven-load characteristics, AGMA has defined the following gearmotor service classes:[7, 8]

CLASS 1: Steady loads not exceeding the normal rating of the motor in 8-hr per day service, or moderate shock where service is intermittent.

CLASS 2: Steady loads not exceeding the normal rating of the motor in 24-hr per day service, or moderate shock for not more than 8 hr per day.

CLASS 3: Moderate shock loads in 24-hr per day service, or heavy shock for not more than 8 hr per day.

Allowable intensity of shock varies inversely with the frequency of peak load occurrence. Permissible peak-load frequency for the various service classes is given in Fig. 43. Service class, plus driven-machine power and speed are information elements that dictate gearmotor rating.

Where coupling of the selected gearmotor to the load is by gearing, chains or belts, overhung-load capacity requires evaluation. In lieu of a stated allowable overhung load, gearmotor data sheets often give the minimum allowable sprocket size that will keep shaft and bearing loads within design limits. These recommended sprocket sizes assume application of the load at the midpoint of the gearmotor shaft extension. As for a separate reducer installation, minimum sprocket diameters must be multiplied by the appropriate overhung-load factor (Table 2) to make allowance for an effective load-application point.

REFERENCES

Applicable standards of the American Gear Manufacturer's Association for geared speed reducers are:

1. "Helical and Herringbone Gear Speed Reducers," AGMA 420.02, Feb. 1951.
2. "High Speed Helical and Herringbone Gear Units," AGMA 421.03, May 1955.
3. "Bevel and Combination Bevel-Helical and Bevel-Herringbone Gear Speed Reducers," AGMA 430.02, Jan. 1954.
4. "Practice for Cylindrical-Worm Gear Speed Reducers," AGMA 440.02, Sept. 1952.
5. "Practice for Double Enveloping-Worm Gear Speed Reducers," AGMA 441.02, Jan. 1954.
6. "Application Classification for Enclosed Speed Reducers," AGMA 151.01, June 1955, (Tentative).

Similarly, standards covering gearmotors are

7. "Practice for Gearmotors," AGMA 460.03, March 1953.
8. "Application Classification for Gearmotors," AGMA 150.01, March 1953.

A comprehensive survey of design features and selection factors affecting choice of the electric motor in a gearmotor unit is presented in

9. John W. Greve—"Electric Motor Drives," MACHINE DESIGN, Vol. 24, No. 4, April 1952, Pages 126-188.

Extra Copies

Extra copies of "Speed Reducers and Gearmotors," bound as a pamphlet, may be obtained for $1.00 each from: Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Induction brazing is widely used for joining parts in high production. High-volume parts produced as one-piece units may show savings by conversion to two-piece brazed assemblies. When volume is high enough to justify the equipment involved, parts originally joined by hand brazing, furnace brazing or arc welding may be readily redesigned for . . .

INDUCTION BRAZING

By A. T. Templin and H. S. Peterson,
Application Engineers
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

INDUCTION brazing can be defined as the process of electrically heating two or more metal parts to the melting point of a nonferrous filler metal which melts at a lower temperature than the parts to be joined. When heated by induction coils, the filler material melts, wetting the surfaces to be joined and creeping into and through each internal surface of the joint by capillary action. There is little oxidation or distortion of the work parts because the annealing is shallow. Heating only the braze area permits minimum heat requirements and facilitates rapid, high-production assembly.

Filler metals considered here are the silver brazing alloys. These fillers melt at temperatures above 1100F. Silver solder is satisfactory for all ferrous and nonferrous metals except aluminum, magnesium, and their alloys, and metals which melt below about 1700 F. Strength of a brazed joint varies with the thickness of the filler material and with the area of the effective joint.

Clean surfaces are essential for satisfactory brazing. These surfaces must be properly cleaned to remove dirt and grease. Fluxes must be applied before joining to dissolve oxides formed during the heating cycle. Parts should be moved slightly with respect to each other instantly after the silver-braze material starts to melt. This wiping action helps the filler to displace the melted flux and permits contact with both joint surfaces. Final design of a joint must always be tested to see that it adequately meets strength requirements.

Strength of properly brazed joints is between the strength of cast brazing metal and that of the base metal. There is no easy "rule of thumb" which can be applied to compare the strength of brazed joints with arc-welded joints. It is possible to burn away part of the parent metal in arc-welding; nevertheless, the butt-welded joint is generally stronger than the butt-brazed joint. However,

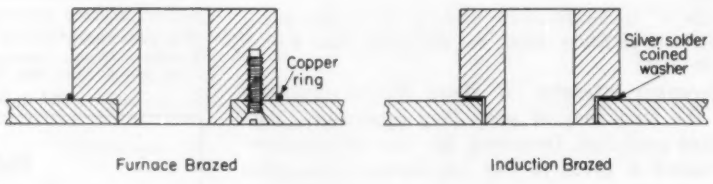
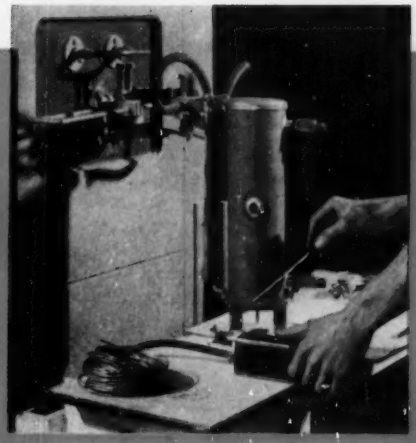
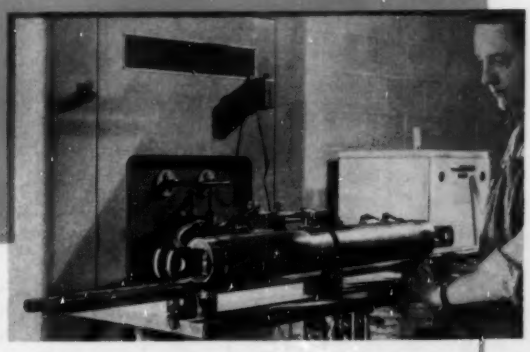


Fig. 1—Simple parts require minor design changes, if any, to adapt them to induction brazing. As originally copper brazed, spud was a press-fit to hole in shell and fastened with screws to prevent shifting in atmosphere furnace. Redesign provides 0.003-0.005-in. clearance between parts and allows reduction of outside diameter by elimination of fasteners.





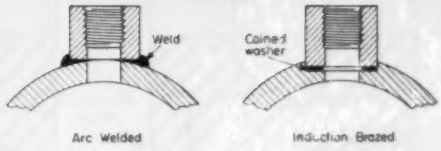


Fig. 2—Redesign of boss, originally arc-welded to cylinder. Parts are assembled with coined silver-alloy washer. By spotfacing shell of cylinder, no precision assembly fixtures are needed to achieve alignment. Silver brazing provides pressure-tight joint.

when a lap-braze joint has a lapping surface area equal to or greater than three times the thickness of the thinner part, the brazed joint is stronger than the thinner parent metal. The joint strength is greatly influenced by the clearance and the resultant filler-material thickness.

Clearance between parts to be joined should be between 0.0005 and 0.003-in. at brazing temperature to insure sufficient room for the filler materials to flow properly between the contacting surfaces. By using preformed silver solder with exactly the right amount of material, waste is eliminated.

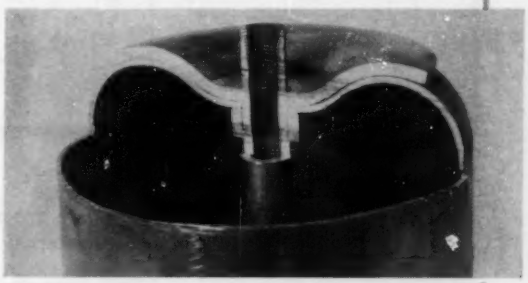
Redesign for induction brazing should be considered if the per-unit production-cost study shows that a savings can be effected or if the product quality can be improved substantially. Thereafter, final justification must be based on the total production quantity involved.

Although the design changes are usually relatively simple, many factors must be considered when such a change is contemplated:

1. Metal parts to be joined and clearance between them.
2. Strength of joint required.
3. Ease of assembly.
4. Ease of applying induction heat.

Many existing assemblies can be readily induction brazed without change. Others may require slight design modifications as indicated in Figs. 1, 2 and 3. A frequently required modification is involved where a relatively thin-walled section is brazed to a heavy part. In such cases, to assure proper heat distribution, the heavy part should be reduced in thickness, as shown in Figs. 4 and 5.

Designers should give careful consideration to the cost of the special preformed brazing alloy



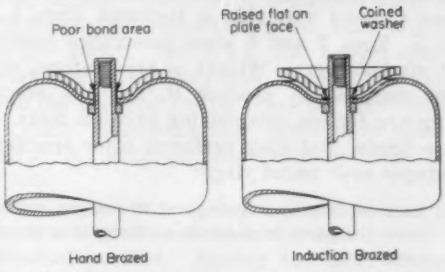


Fig. 3—Oil filter assembly requires pressure-tight bond between shell, tube, and reinforcing plate. Original hand brazing had insufficient control of heat, resulting in leaking joints. By coining flat surface on reinforcing plate and using a coined silver-solder washer, defective assemblies were eliminated. Heat is applied from inside the shell. Improved conduction through flat area on reinforcing plate, and wiping action from settling of plate when material melts, assures acceptable bond.

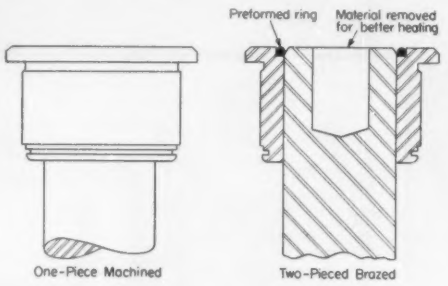


Fig. 4—Hydraulic ram assembly was originally machined from solid bar stock. Redesigned assembly resulted in large material savings. One piece unit was carburized and hardened. In redesigned unit, only the rod is case hardened and ground (before brazing). Annealing of surface of rod is restricted to 1 in. below end of sleeve. Removal of stock at end of rod improves heating.

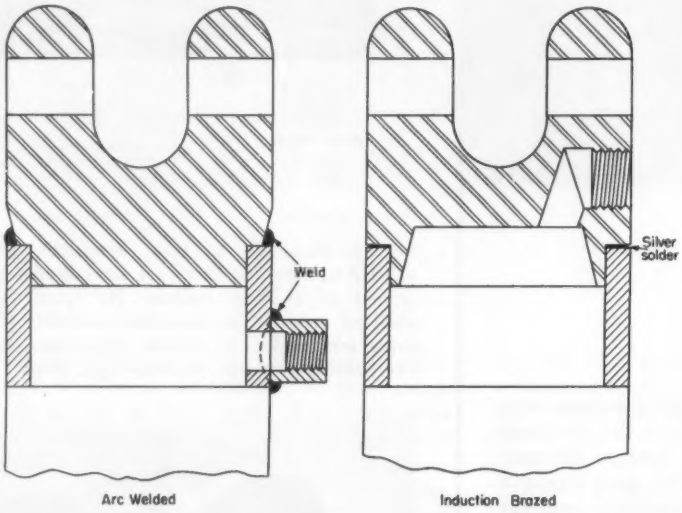


Fig. 5—Redesign of arc-welded clevis and cylinder assembly involved locating inlet in clevis to eliminate one bond. Removal of material from clevis improves heating and original press fit was changed to 0.0025-in. clearance. Unit is brazed in a vertical position with heat provided by two coils. As silver solder preform melts, clevis settles into position.

employed. Round wire rings, Fig. 6, are generally the least expensive. Depending on internal and external diameters, the flat washer preform is generally the most expensive. A coined washer results when a round wire ring is flattened, Figs. 1, 2, 3 and 5. Figs. 7 and 8 show assemblies employing flat ring washers. Weight of the preform, operations required to produce it, and the resulting scrap are factors determining preform costs. For some joints, flat ring preforms offer specific advantages over round rings:

1. Less depth of machining cut to remove material from the parts in order to accommodate the preform.
2. Greater area of contact between brazing matrial and mating surfaces results in better heat conduction and improved capillary flow of filler.
3. When one of the parts is heated principally through conduction from the mating part, a flat ring melts sooner and flows better.
4. Flow and wetting characteristics are better. This results in fewer voids from overheating or oxidation.

Brazing will join parts produced by different processes, such as stampings, forgings, screw-machine products, cold-headed parts, or tubular sections into an assembly which is impractical or uneconomical to make in one part. Parts made of

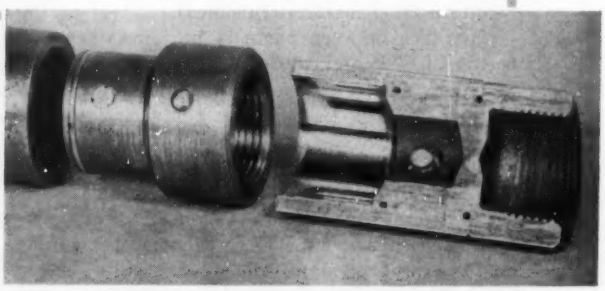


Fig. 6 — Threaded head is induction brazed into end of hydraulic cylinder. Notice honed interior of cylinder and use of two round-wire preforms to provide sufficient filler material to braze long contact surface.

the same metal are usually easier to design for brazing than dissimilar metals. Although it is possible to braze ferrous metals very successfully, certain precautions must be taken, or results may not be satisfactory. Poor results are frequently encountered when a metal with a high coefficient of expansion is placed inside a metal having a lower coefficient.

Size of parts which can be induction brazed varies from small silver contacts on electrical switches to parts weighing many pounds. Strength

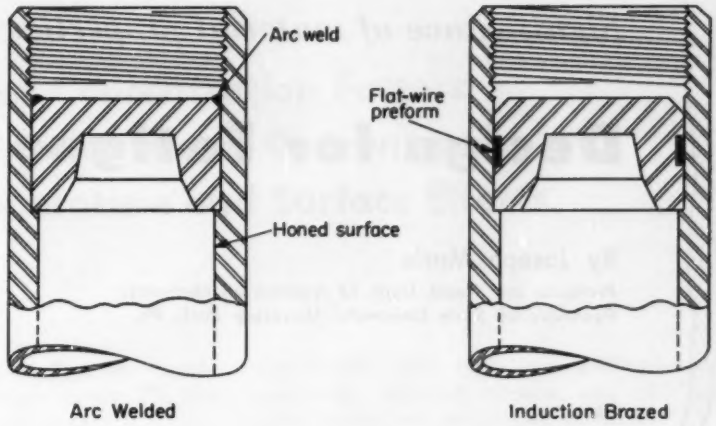


Fig. 7 — Assembly of cylinder plug requires a hermetic bond and protection of honed surface of cylinder. Original pressed-in, arc-welded design was modified to allow 0.002-in. clearance per side. Shallow groove for flat-wire preform speeds machining. Flat ring provides high heat conduction and good capillary flow.

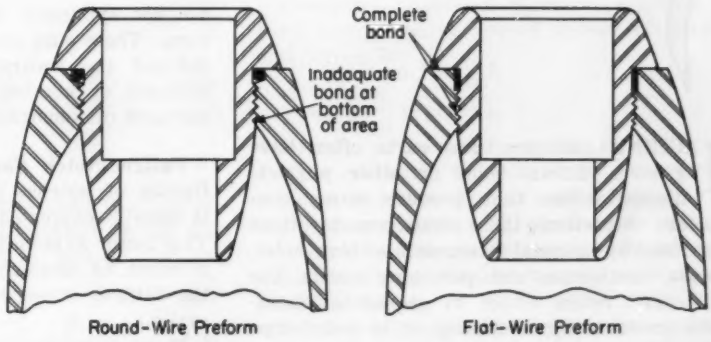


Fig. 8—Projectile assembly utilizes advantages of flat-wire preform. With original round wire, difficulty was encountered in achieving proper penetration of filler metal between threads. Better melting and wettability of flat wire provide complete bonding.

required, power available or needed, and handling problems generally determine the upper size limits for practical induction brazing. Heavy sections can generally be welded more economically.

Ease of assembly is especially important when production rates are high. Greater permissible tolerances result in lower manufacturing costs. Generous clearances between parts to be assembled also yields cost savings. However, clearances in excess of 0.006-in. should be avoided if at all possible, because joint strength sharply decreases when excess filler material is used. Properly designed silver brazing preforms will permit rapid assembly and insure uniform quality of the brazed joints.

An important design consideration is the placement of parts to be brazed in proximity to the induction-heater work-coil. Usual clearance between the assembled parts to be brazed and the coil is approximately 1/16-in. to ⅛-in. At no time should parts contact the work coil. When production rates are high, special jigs and fixtures can be utilized to move parts into and out of the work coil of the heater.

Induction heater work coils can be made to surround the parts or the parts to be heated may surround the coil. In some cases, coils are made to do both. A design which permits easy loading into a coil can save the cost of expensive jigs and fixtures. Furthermore, the time saved in reloading can increase production output of the heater. Work coils vary in cost depending upon their complexity. Most of them range in price from fifty to several hundred dollars. The cost of a specific work coil can be readily determined after the exact requirements are known. Work coil cost covers design, materials, manufacturing and testing. Of these factors, the material cost is often the least expensive. Many induction-heater users have become proficient in designing and building their own work coils.

Design engineers should weigh all factors affecting the cost of manufacturing and quality of the finished product. Among the more obvious factors are:

1. Is production demand adequate to consider the investment for induction brazing?
2. What type of brazed joint will provide adequate strength?
3. How will the effect of additional machining, if any, influence comparison with previous cost?
4. Will the cost of silver-brazing alloy offset other savings?
5. How will the labor cost for the induction-brazing compare with the previous method?
6. If several parts are to be induction brazed, can they be handled by the same size unit merely by changing the work coil?

Significance of material properties in

Design for Fatigue Loading

By Joseph Marin

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MACHINE and structural parts often have grooves, fillets, holes or other physical discontinuities that produce stress concentrations. Sometimes these stress concentrations are produced by material flaws, such as blow-holes, inclusions, laminations and quenching cracks. The term "notch" refers either to geometric discontinuities produced by machining, or to metallurgical discontinuities caused by flaws. The presence of such notches reduces the strength or load-carrying capacity of a member because combined stresses are introduced at notches and because the maximum principal stress increases at the notch.

Stress-Concentration Factors

Reduction in fatigue strength, resulting from the presence of various stress raisers, such as grooves, holes, threads and fillets, has been studied by many investigators. Various methods of interpretation of fatigue-test results for notched specimens have been used.[71] None of these methods, however, gives a complete interpretation. The problem is complicated by the many factors that influence the behavior of a notched specimen subjected to fluctuating stresses.

In a notched specimen, triaxial stresses with variations in the state of stress throughout the cross section are produced. Because of this stress gradient and variation, shape and size of the specimen have an influence on its strength. Furthermore, when plastic flow occurs during the fatigue life of the specimen, reduction and redistribution of stresses result. The method of stress calculation based on the elastic theory is then inapplicable. Similarly, theories of yield strength are not applicable if appreciable plastic flow occurs. These and other complications have made difficult the accurate prediction of the fatigue strength of notched specimens from the fatigue strength of unnotched specimens.

Fatigue-Notch Factors: A measure of the influence of notches as obtained from test results is usually expressed by the *fatigue-notch factor*. This factor k_f is defined as the ratio of the fatigue strength of unnotched specimens at N cycles to the fatigue strength of notched specimens at N cycles.

Tests show that the value of the fatigue-notch factor k_f is less than the theoretical static stress-concentration factor k_t based on the theory of elasticity, where the theoretical stress concentration k_t is defined as the ratio of actual maximum stress at the notch to the nominal stress based on elementary formulas.

The value which the theoretical stress concentration attains in fatigue is measured by the *notch-sensitivity factor*, which is defined as

$$q = \frac{k_f - 1}{k_t - 1} \qquad (79)$$

The relationship between the notch-sensitivity factor q and the theoretical stress-concentration factor k_t is shown in Fig. 30. A value of $q = 1$ occurs for $k_t = k_f$. The complexities involved in interpreting the fatigue strength of notched specimens are due to the fact that q depends not only upon the properties of the material, but also upon shape and size of the specimen.

Provision for fatigue stress concentration in design is usually made by introducing the *fatigue-notch factor* (sometimes referred to as the *fatigue-reduction factor*) in the working-stress relation.

A modification in this procedure is suggested by Peterson.[21] This modification considers the *combined stress effect* at a notch. A combined stress-concentration factor k_t' as applied to notches is defined as the theoretical stress-concentration factor which takes into account the effects of stress concentration and combined stresses. Peter-

[71]References are tabulated at end of article.

Part 5 Stress Concentration Factors Design for Stress Concentration Temperature and Surface Effects

son bases the combined stress effect for ductile materials on the distortion-energy theory. On this basis the relation between k_t and k_t' is

$$\sigma_1^2 - \sigma_1 \sigma_2 + \sigma_2^2 = \sigma_e^2 \tag{80.1}$$

or

$$\left(\frac{\sigma_1}{\sigma_n}\right)\left(1 - c + c^2\right)^{1/2} = \frac{\sigma_e}{\sigma_n} \tag{80.2}$$

or

$$k_t\,(1 - c + c^2)^{1/2} = k_t' \tag{80.3}$$

where σ_n = the nominal stress, and $c = \sigma_2/\sigma_1$.

From Equation 79, the theoretical factor k_{tf}' can be expressed in terms of k_t' and q. That is,

$$k_{tf}' = q(k_t' - 1) + 1 \tag{81}$$

From available notch-sensitivity data, values of k_f or k_{tf}' can be obtained from Equation 79 or 81. For determining these values, graphs are available showing variations in notch sensitivity with notch radii for various materials and types of notches. Application of stress-concentration values in design is outlined in the following section.

Design for Stress Concentration

Working relationships used in design of members subject to stress-concentration effects depend, in general, upon the nature of the fluctuating stress. Two types are distinguished: (1) completely reversed stresses, and (2) superimposed static and alternating stresses.

Completely Reversed Stresses: Working stress for a grooved bar subjected to completely reversed axial stress is

$$\sigma_a = \frac{\sigma_e}{k_{tf}'\,N} = \frac{\sigma_e}{[q(k_t' - 1) + 1]N} \tag{82}$$

where σ_a = the axial nominal stress, σ_e = the fatigue strength for completely reversed axial stresses, and N = the factor of safety. In evaluating σ_a from Equation 82, the designer may obtain the theoretical stress-concentration factor k_t' from Equation 80, and the notch-sensitivity values from published data.[21]

In view of the limited knowledge available on fatigue stress-concentration factors for brittle materials, use of the theoretical factor k_t in place of the fatigue factor k_{tf}' is recommended.[21]

For grooved bars of ductile materials subjected to both reversed axial loads and reversed torsion, the working-stress design relation based on the distortion-energy theory becomes

$$(k_{tf}'\,\sigma_a)^2 + 3(k_{tsf}\,\tau_a)^2 = \left(\frac{\sigma_e}{N}\right)^2 \tag{83}$$

where $k_{tsf} = q(k_{ts} - 1) + 1$, k_{ts} = the theoretical static stress-concentration factor considering the combined stress effect, and τ_a = the reversed nominal stress amplitude.

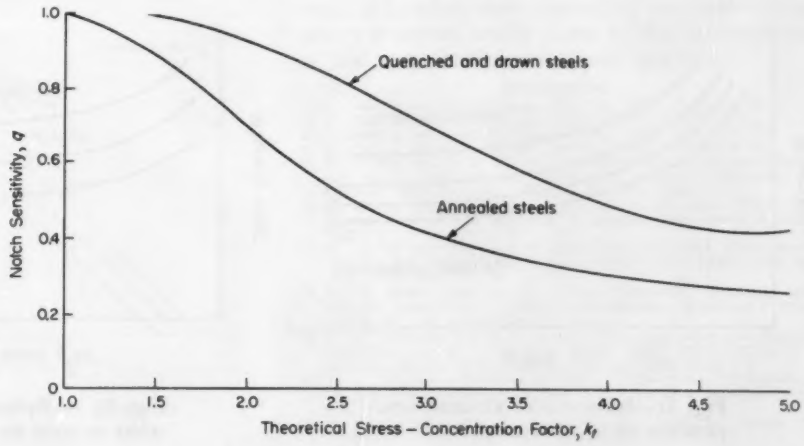

Fig. 30—Notch sensitivity of steels. Curves represent average values for V-notch transverse holes, circular fillets, and semicircular grooves.

For brittle materials and completely reversed combined stresses, the Mohr theory has been recommended.[21]

Superimposed Static Stresses: For ductile materials and fluctuating axial stresses in a grooved bar, with nominal mean stress σ_m and nominal alternating stress σ_r, various procedures have been suggested to provide for stress-concentration effects. The most common method is to apply a stress concentration factor to the alternating stress σ_r only, and to assume that plastic flow has removed the static stress concentration. On this basis, the modified Goodman relation, Equation 44, gives the design equation,

$$\frac{N}{\sigma_e}(k_{tf}\,\sigma_r) + \frac{N\,\sigma_m}{\sigma_u} = 1 \qquad (84)$$

where N, the factor of safety, is assumed to be the same for both static and fatigue stresses.

From the Soderberg straight-line relation, Equation 45, the design relation for axial stress is derived as

$$\frac{N}{\sigma_e}(k_{tf}\,\sigma_r) + \frac{N\,\sigma_m}{\sigma_{yp}} = 1 \qquad (85)$$

For combined fluctuating stresses in ductile materials, the maximum shear theory and the uniaxial design equation, Equation 85, have been recommended.[16, 21]

For brittle materials, Peterson[21] suggests that the theoretical stress-concentration factor be applied to both the static and alternating stress components. Thus, Equation 84 is replaced by

$$\frac{N}{\sigma_e}(k_t\,\sigma_r) + \frac{N}{\sigma_u}(k_t\,\sigma_m) = 1 \qquad (86)$$

For combined fluctuating stresses and brittle materials, the Mohr theory has been recommended.[21]

Modified Working Relationships: Although the foregoing methods of providing for stress concentration in fatigue are acceptable, it is believed that the following simpler and more general method could be used.

In Equation 84 for axial fluctuating stress in a grooved bar, a stress-concentration factor is applied to the alternating part of the stress only. The assumption is that plastic flow makes it unnecessary to apply a stress-concentration factor to the static part of the stress. This procedure has been justified on the basis that it gives best agreement with test values. It should be realized, however, that for certain combinations of stresses σ_r and σ_m, and strength values σ_e, the stress σ_m may be in the elastic range or in the initial part of the plastic range. Under these circumstances, static stress concentration cannot be neglected. Lack of sufficient test data on this problem supports the proposal that a stress-concentration factor be applied to the static mean stress σ_m, since this leads to conservative design. In applying a stress-concentration factor to mean stress σ_m, the designer should use the plastic theoretical stress-concentration factors (if such values are available), rather than the stress-concentration factors for the elastic range. Then, to provide for stress concentration, the general uniaxial failure relation, as expressed by Equation 47, is replaced by

$$\left(\frac{k_{tf}\,\sigma_r}{\sigma_e}\right)^n + \left(\frac{k_t\,\sigma_m}{\sigma_u}\right)^m = 1 \qquad (87)$$

where k_t is the static "elastic" or "plastic" stress-concentration factor.

Application of factors of safety N_e and N_u to Equation 87 gives the design relation for uniaxial stresses:

$$\left[\frac{N_e}{\sigma_e}\left(k_{tf}\,\sigma_r\right)\right]^n + \left[\frac{N_u}{\sigma_u}\left(k_t\,\sigma_m\right)\right]^m = 1 \qquad (88)$$

For completely reversed combined loads, it is recommended that Equation 63, with corrections for stress concentration, be used for both ductile and brittle materials. If the loads are not completely reversed, Equation 74 can be used for both ductile and brittle materials, providing stress-concentration factors are introduced.

Design relations for combined stresses, including the effect of varying stress amplitudes and

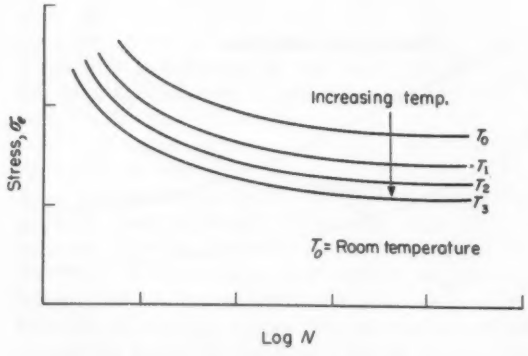

Fig. 31—Influence of elevated temperature on σ_e—N curves.

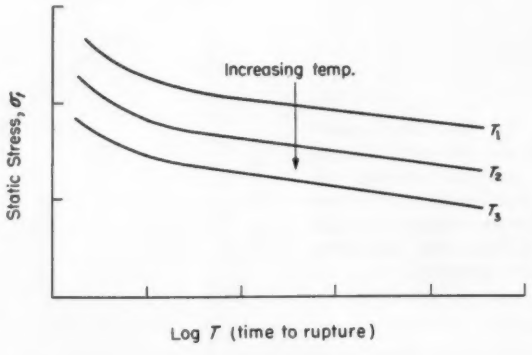

Fig. 32 — Relationship of static stress to time to rupture.

number of stress cycles, can also be obtained from relations given in Part 3 of this series.

Other Design Factors

Many factors other than strength must be considered in the design of members subjected to fatigue loads. Effects, such as temperature and creep, corrosion and damping, may greatly influence the design stresses that are selected. Surface effects, including surface roughness and residual stresses, also modify the fatigue strength of parts. Some of these considerations are discussed here.

Elevated Temperatures: For members subjected both to fatigue loading and to elevated temperatures, the designer must guard against two possibilities: (1) failure by fatigue, and (2) failure by excessive creep deformation produced by the elevated temperature. The characteristic distinguishing these two events are that creep is a time-dependent phenomenon, while fatigue failure depends upon the number of load cycles. In the latter case, frequency of the fluctuating stress must be considered. Considerable data have been obtained on the effect of elevated temperature on fatigue. Some of these results are reported in References 23, 27, 33 and 72 to 75.

Illustration of the influence of elevated temperatures on fatigue strength (completely reversed stress) is given by the σ_e—N diagrams of the type shown in Fig. 31.

For the case of combined static and alternating stresses and high temperatures, static creep-rupture data like that shown in Fig. 32 are obtained. Failure relations based on fracture for various combinations of alternating and mean stresses are plotted in Fig. 33.[73] For failure defined by N_1 cycles, as represented by curve AB, point B is the stress at rupture for the time represented by N_1 cycles and for the particular temperature considered. Point A represents the fatigue strength for complete stress reversal at N_1 cycles at the reference temperature. Points along the curve AB correspond to fracture produced under combinations of both static and alternating stresses. For design purposes, the failure relation AB, Fig. 33, can be expressed by the elliptical relation, [76]

$$\left(\frac{\sigma_r}{\sigma_{et}}\right)^2 + \left(\frac{\sigma_m}{\sigma_{tt}}\right)^2 = 1 \qquad (89)$$

where σ_{et} and σ_{tt} are, respectively, rupture strength values for completely reversed and static stresses, corresponding to N_1 cycles and temperature T_e.

Relations similar to those in Fig. 33, with the exception that curves are plotted for a certain percentage total strain rather than fracture, are given in Reference 75.

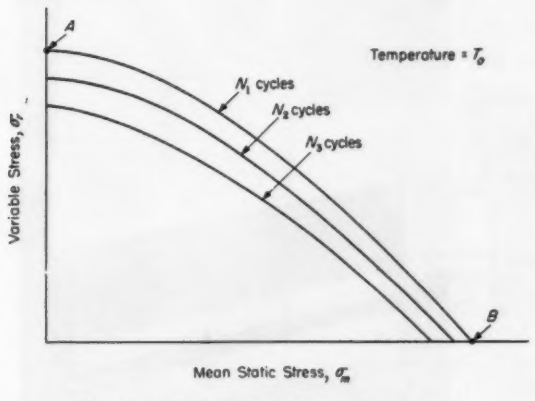

Fig. 33—Influence of mean stress on failure by fatigue and creep.

Fatigue and Damping: For machine and structural parts which may be subjected to near-resonant vibrations, the fatigue strength of the material is not a sufficient basis for design. The internal damping properties of the material must also be considered. A survey on determination of damping and criteria for design based on both damping and fatigue-strength properties of materials are presented in Reference 24.

Miscellaneous Design Considerations: The surface condition of members subjected to fatigue is important because most failures in fatigue start at the surface. Three surface conditions may influence the fatigue strength of members: (1) roughness of the surface, (2) difference between the strengths of the core and outer shell, and (3) residual stresses in the surface layers. The influence of surface effects on fatigue strength is discussed in detail in Reference 23.

In using the data from laboratory specimens, the designer must consider the many differences between the part to be designed and the small laboratory specimen. Because of these differences it is sometimes necessary to conduct fatigue tests on component parts of machines and structures.

In the selection of design stresses, methods to be used for fatigue-crack detection and provisions for inspection are important considerations.[23] Although the designer should consider all possible ways of increasing the fatigue strength of materials, it is often more important to observe good design practices which relate to the configuration of the part (References 23, 27 and 77).

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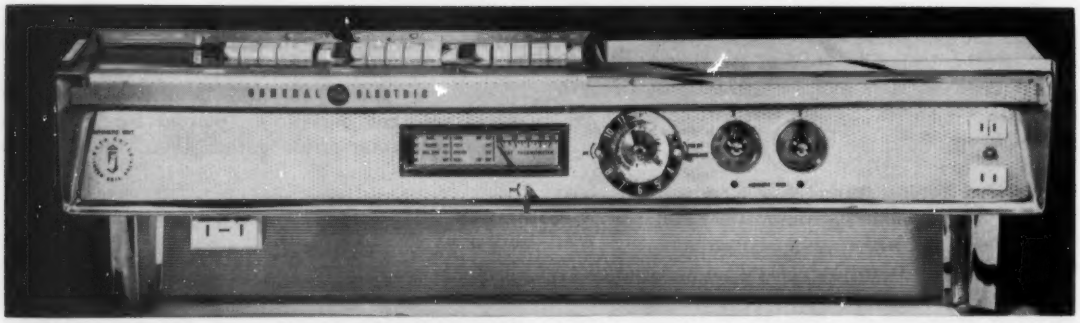
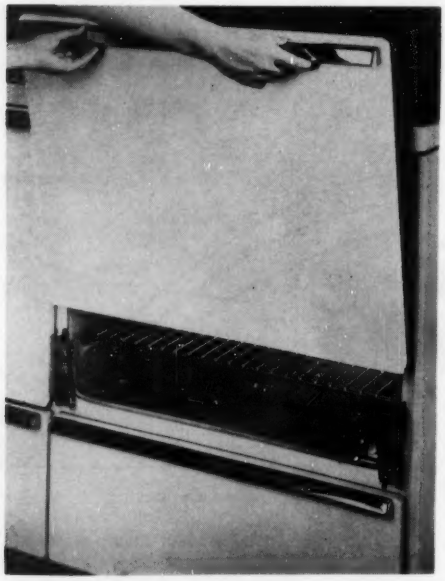
Piano-Key Controls and Removable Doors Are Design Features in Electric Range



Lighted piano-key pushbutton switches control three of the four surface units in the new G.E. Liberator electric range. Temperature of the left-front unit is set by a continuously adjustable slide type control. Internal meat temperature is registered on a meat-thermometer dial sensed by a plug-in probe.

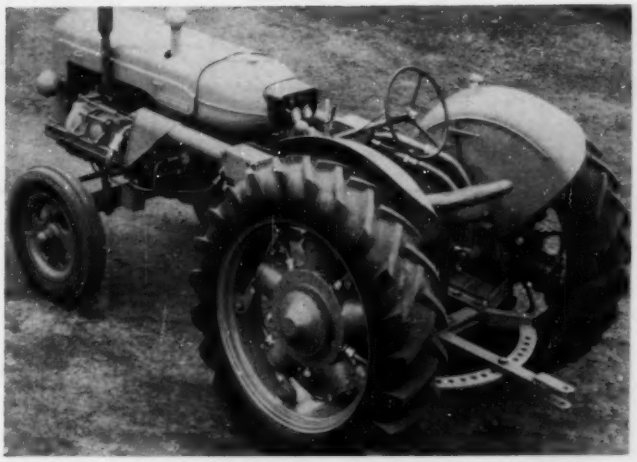
Removable oven-door design permits easy cleaning. Either door is removed by opening to the "broiler-stop" position and lifting the handle in an upward direction.

Plugging in the aluminum grill parallel-connects both the front-left and back-left surface units. Temperatures of both units are then thermostatically regulated through the slide control. The grill itself incorporates neither controls nor heating elements.



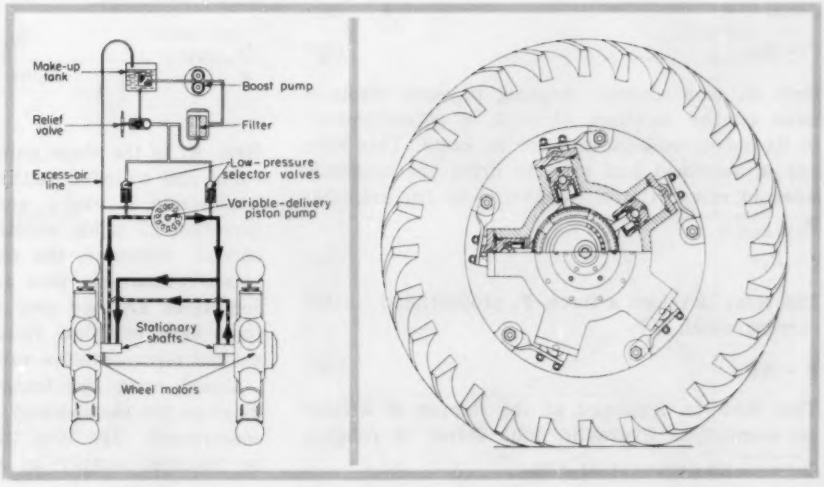
Hydraulic Motors Mounted Inside Rear Wheels Propel Tractor

An all-hydraulic drive for a diesel-powered agricultural tractor has been developed by the National Institute of Agricultural Engineering, Silsoe, England. The tractor operates at any speed between 0 and 6 mph. Overall efficiency exceeds 85 per cent at 3 mph.



In operation, power from the engine drives a variable-displacement pump which has a rotary block with cylinders parallel to the axis. Pistons in this pump are linked to a ring whose angle of tilt is changed to vary stroke and, in turn, volume is displaced. When the ring is normal to the axis, both pump stroke and output are zero. Direction of oil flow, which determines whether the tractor will move forward or backward, is reversed by changing angle of tilt of the pump ring from positive to negative or vice-versa. Fluid is forced from the pump to the five-cylinder radial motors mounted in the rear driving wheels of the tractor. Torque applied to the wheels, as well as speed of wheel rotation, is varied by changing both angle of tilt of the pump ring and pump speed. The wheels are braked when the pump ring is moved to a neutral position.

The hydraulic motors, located inside the driving wheels, are equipped with cylinder blocks that turn with the wheels about stationary shafts; large eccentric members are securely mounted on each shaft. Thrust from the motor pistons is transmitted through piston rods to metal shoes that bear against a roller-bearing race ring on each eccentric. Hydraulic fluid is delivered to the motors via annular passages in each stationary shaft, with flow to cylinders controlled by valves bearing on circular plates. Oil exhausted from the motors is returned through an annulus in a sleeve around the fixed shafts. At 2600 psi the ring shoes take a piston thrust of approximately 35,000 lb. Since the two motors are connected in parallel, differential action between them is automatic and a slowing of one wheel motor causes increased oil flow to the other.



Illustrations, courtesy Electrol Inc.

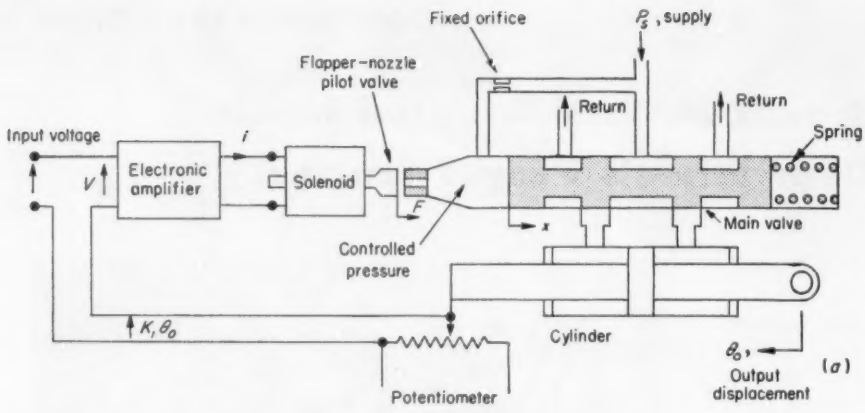


Fig. 19—In this valve-cylinder servomechanism, input is a voltage which is electronically amplified and used to control a solenoid valve. Feedback quantity is also a voltage supplied by a potentiometer connected to the output device, a hydraulic cylinder. A schematic diagram is left at *a*. A block diagram for the system is right at *b*.

Hydraulic Servos—3

By J. M. Nightingale, *Manchester, England*

METHODS for analyzing a practical servo system of the valve-cylinder type were discussed in earlier parts of this article.[9, 10] This part will extend the frequency response methods to more complicated systems. The system to be considered, Fig. 19*a*, includes an electronic amplifier, a magnetic relay and a hydraulic pilot valve in addition to a valve-cylinder relay such as was discussed before. In this instance the hydraulic relay is an open-loop device.

System Equations: Equations relating input and output for this system are:

$$e = \theta_i - \theta_o \tag{32}$$

$$V = K_1 e \tag{33}$$

Here K_1 is a constant relating physical displacement of the feedback element, a potentiometer, to its output voltage in v per in. units. This voltage is amplified and used to drive the magnetic solenoid relay. Current delivered by the amplifier is

$$i = K_2 V \tag{34}$$

The relay develops a force, F, proportional to this current which is

$$F = K_3 i \tag{35}$$

This force is developed at the flapper of a flapper-nozzle-type hydraulic pilot valve. A roughly proportional pressure is developed in the chamber of the pilot valve and this in turn produces a proportional displacement of the main valve spool. The transfer function relating the main spool displacement with the flapper force includes a simple time lag term and is, therefore,

$$\frac{x}{F}(s) = \frac{K_4}{1 + Ts} \tag{36}$$

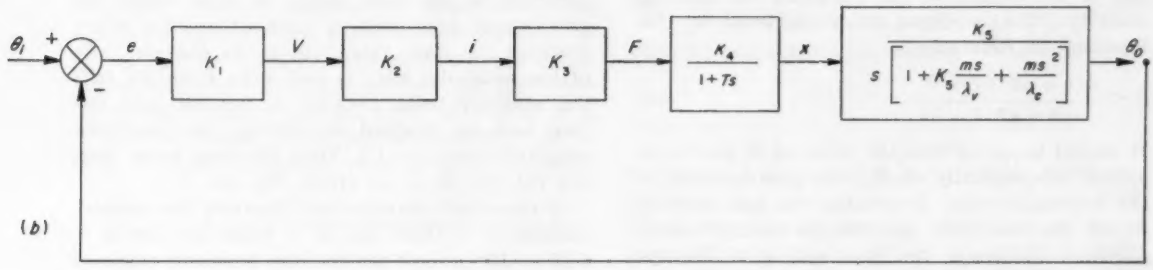
Finally for the open-loop valve-cylinder relay the transfer function will be of the form given in Equation 16[10], assuming that the output load is simply an inertia.

$$\frac{\theta_o}{x}(s) = \frac{K_5}{s\left(1 + \frac{K_5 ms}{\lambda_v} + \frac{ms^2}{\lambda_c}\right)} \tag{37}$$

Here K_5 is the slope gain constant, and λ_v, λ_c the valve and cylinder "stiffnesses" described earlier. Once again, K_5 and λ_v are not truly constants, and Equation 37 holds strictly only for small disturbances. However, the techniques adopted to obtain a panoramic view for all possible operating conditions are not easy to apply as systems become more complex. Here K_5 and λ_v must be considered representative values.

Based upon the foregoing equations, a block diagram for the complete system, Fig. 19*b*, can be constructed. The loop transfer function can now be obtained simply by multiplying the transfer

[9]References are tabulated at end of article.



Practical methods for analyzing typical systems

functions of each box in the forward path.

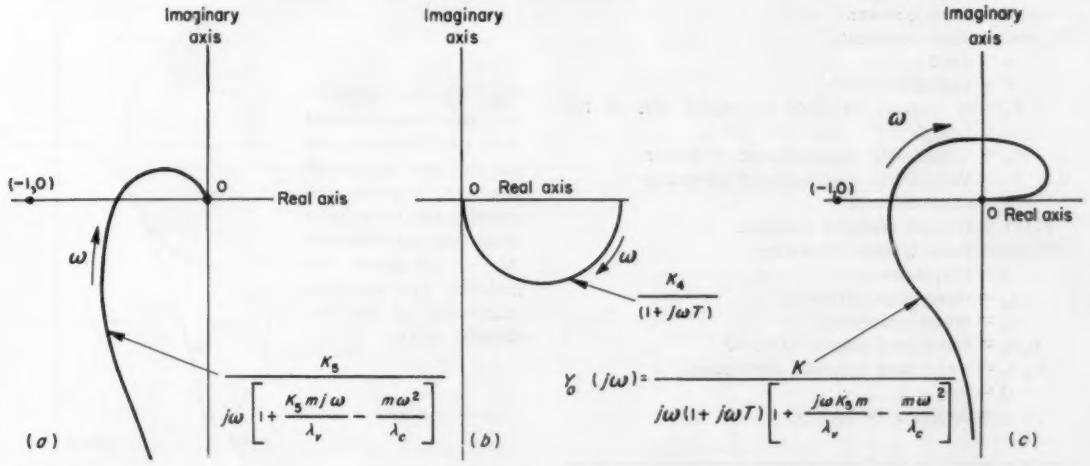
$$Y_o(s) = \frac{\theta_o}{e}(s) = \frac{K}{s(1+Ts)\left(1 + \frac{K_5 ms}{\lambda_v} + \frac{ms^2}{\lambda_c}\right)} \quad (38)$$

For the sake of simplification, $K = K_1K_2K_3K_4K_5$ = net loop gain constant. The overall, or closed loop, transfer function is

$$Y_c(s) = \frac{\theta_o}{\theta_i}(s) = \frac{K}{bTs^4 + (aT+b)s^3 + (a+T)s^2 + s + K} \quad (39)$$

where $a = K_5m/\lambda_v$ and $b = m/\lambda_c$ have been in-

Fig. 20—Nyquist plots for, *a*, the main valve and cylinder, *b*, the flapper-nozzle pilot valve and main valve spool and, *c*, the open-loop plot for the entire system shown in Fig. 19. Note that this open-loop plot approaches the critical point more closely than the plot for the hydraulic relay alone.



troduced to simplify this expression.

Performance: First step in analysis of this system is to investigate the condition for absolute stability. The condition to be achieved is (See Equation 15, Reference 3)

$$K \leq \frac{a(b + aT + T^2)}{(b + aT)^2} \qquad (40)$$

It should be noted that the value of K can be adjusted independently of K_5, the gain constant of the hydraulic relay. In practice the gain constant K_2 of the electronic amplifier is usually readily adjusted to change the gain setting of the system. Thus K_5 can be fixed at a value suitable for the design of the hydraulic relay. From gain margin considerations, K should be about ¼ of the right-hand side of Equation 40 or less.

Now it is necessary to optimize the parameters of the system to obtain suitable performance. Either frequency or transient response methods can be used. In view of the complexity of the transfer functions frequency response methods are preferred. Characteristics of those components which are dependent on frequency are plotted in Figs. 20*a* and 20*b*. With suitable change of scale to include the effect of other scalar gain constants in the loop they may be combined to give the loop harmonic response locus or Nyquist plot, Fig. 20*c*. Effect of the time lag T in the pilot valve is to place the locus of the hydraulic relay in the instability region, and for suitable stability the product of the gain constants, $K_1\ K_2\ K_3\ K_4$, must generally be less than unity. In other words the error signal must undergo some attenuation before reaching the main valve, unless the characteristic of the hydraulic relay is well away from the critical stability point $(-1,0)$. A suitable gain setting may be obtained by limiting the maximum amplitude ratio to 1.5. Thus the loop locus must not cut the $M = 1.5$ circle, Fig. 21.

A numerical example will illustrate the method. Assume $T = 0.003$ sec, $a = 0.010$ sec, and $b = 6.25 \times 10^{-6}$ sec.^{2} Then the loop harmonic response function is

$$\frac{\theta_o}{e}(ju) = \frac{K'}{ju(1 + 3\,ju)(1 + 9.3\,ju)(1 + 0.67\,ju)} \qquad (41)$$

For convenience $u = 0.001\omega$ and $K' = 0.001K$. Note that the quadratic term in the denominator can be factored. The locus of this function for varying u is plotted in Fig. 21. If the maximum amplitude ratio is to be 1.5 then the scalar gain constant K must be set at 100. The bandwidth is approximately 16 cps. From Equation 38 it can be seen that the servo is of the first order.[4] The steady following error for a constant velocity input of 1.0 in. per sec, given by $1/K$, is therefore 0.010-in.

In this example an expression has been obtained only for the optimum gain constant; the other parameters have been determined by some prior considerations. However, it is quite likely that at an initial design stage there will be quite a degree of freedom of choice among the various parameters of the complete system. It, therefore, seems desirable to obtain some relations among the parameters in order to achieve a certain performance. One way this might be attempted is to obtain an algebraic expression by limiting maximum M to 1.5 in the expression for the overall harmonic-response function. This method was em-

Nomenclature

- a, b = System parameters
- B = Leakage coefficient; leakage flow = BP_c
- e = Error
- F = Force
- f = Damping coefficient
- I = Inertia on output shaft
- i = Current
- K = Total gain constant of loop
- $K' = K/1000$
- K_1, etc. = Scalar gain constants
- m = Mass
- N = Bulk modulus of fluid
- P_c = Differential pump pressure
- r = Gear train ratio
- s = Laplace operator
- T = Time constant
- T_1, etc. = Time constants
- $u = 0.001\ \omega$
- V = Voltage
- V_c = ¼ volume of fluid on motor side of the pump
- V_m = Volumetric displacement of motor
- V_p = Volumetric displacement of pump
- x = Displacement
- $Y_c(s)$ = Overall transfer function
- $Y_o(s)$ = Loop transfer function
- y = Displacement
- η_g = Gear train efficiency
- η_m = Motor efficiency
- θ_i, θ_o = Input and output of servo
- λ_v, λ_c = Valve and cylinder stiffnesses
- $\Omega = 0.01\ \omega$
- ω = Angular frequency

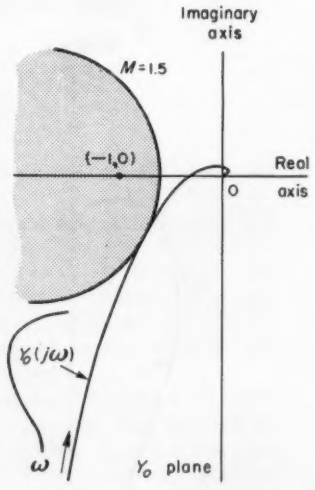


Fig. 21—In addition to the requirement that the Nyquist plot should not approach the −1, 0 point too closely, the loop locus must not intersect the $M = 1.5$ circle for stability. This prevents instability of the hydraulic relay.

ployed quite successfully for the closed-loop hydraulic relay. But now the system is more complex and the algebraic expressions involved are almost unmanageable. It is, however, possible to obtain a set of relations by transient response considerations provided a slightly overdamped response can be tolerated. The method involves the use of Whiteley's coefficients (Page 109, Reference 4). In the present case the order of the servo is 1, and the degree of the denominator of $Y_o(s)$ is $n = 4$. Then Whiteley's table gives an optimum loop transfer function of the form

$$Y_o(s) = \frac{\Omega^4}{s(s^3 + 2.6\,\Omega\,s^2 + 3.4\,\Omega^2\,s + 2.6\,\Omega^3)} \qquad (42)$$

Now Equation 38 can be written in the same form:

$$Y_o(s) = \frac{\dfrac{K}{bT}}{s\left(s^3 + \dfrac{aT+b}{bT}s^2 + \dfrac{a+T}{bT}s + \dfrac{1}{bT}\right)} \qquad (43)$$

Then by equating similar coefficients of Equations 42 and 43, $K/bT = \Omega^4$, $1/bT = 2.6\Omega^3$, $(a + T)/bT = 3.4\Omega^2$, and $(aT + b)/bT = 2.6\Omega$. Now the transient response is determined by the parameter Ω. The relationship among the coefficients in Equation 42 insures that the maximum overshoot for a step function input is limited to 10 per cent of the step, while the buildup time is given by $T_b = 4.2/\Omega$. Therefore, by fixing a suitable build-up time and hence Ω, four relationships between the parameters a, b, T, K are obtained. It is possible to solve these, but this is a difficult task since it involves the explicit solution of a cubic equation. However, it is possible to obtain a graphical solution quite easily. Suppose the desired buildup time is 0.016 sec. This gives $\Omega = 260$. Direct substitution in the first two equations obtained by equating coefficients of Equations 42 and 43 gives $K = 100$. Substituting for Ω in the other two relations yields the expressions

$$\left.\begin{aligned} a - T &= 0.005 \\ a &= \frac{14.8\,T - 0.022}{10^6\,T^2} \end{aligned}\right\} \qquad (44)$$

Plotting a against T in these equations, Fig. 22,

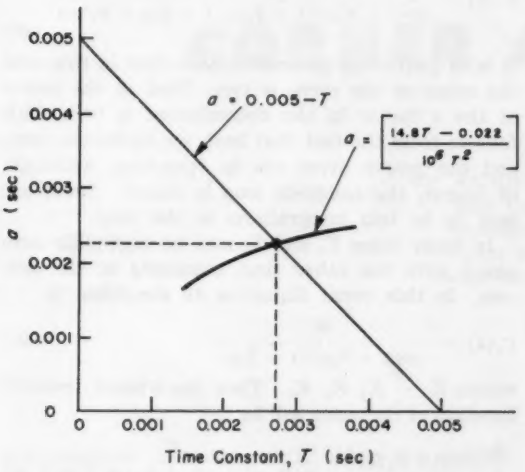
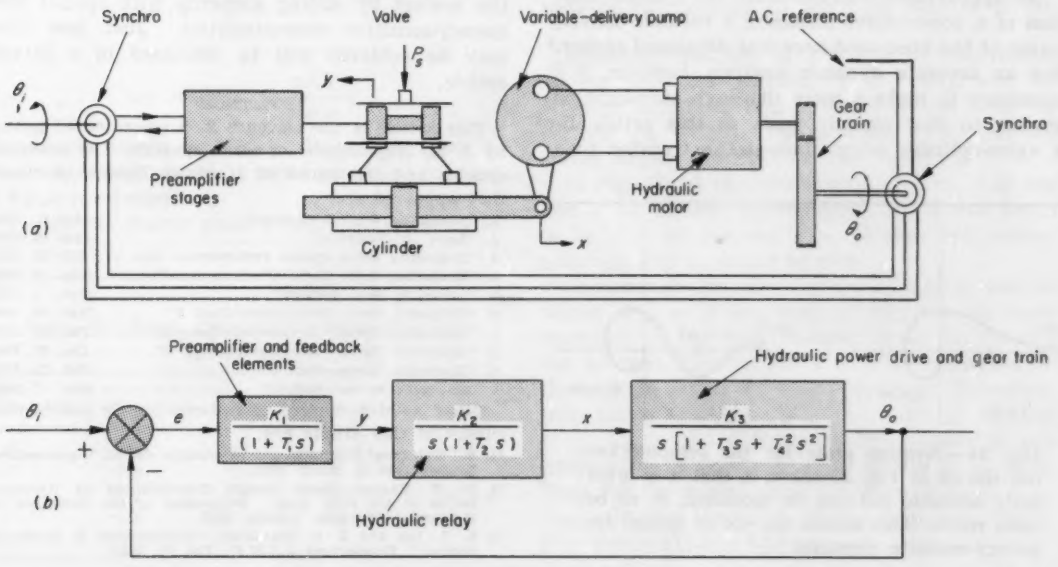


Fig. 22—Optimum values of a and T are established by plotting the two expressions involving these quantities. The point of intersection gives the required values.

Fig. 23—A valve-cylinder relay is used as a power amplifier in this servomechanism to control hydraulic pump displacement. Output device is a hydraulic motor driving a gear train. Schematic, *a*, and block diagram of the system, *b*, are shown.



yields the desired values of a and T at the intersection. The values for all the parameters are: $a = 0.0023$ sec, $b = 8.1 \times 10^{-6}$ sec^2, $T = 0.0027$ sec, and $K = 100$. In this case the following error for a constant-velocity input of 1.0 in. per sec is 0.010-in.

The sort of delays in the hydraulic relay inferred by the values of a and b obtained are quite small and in practice may be difficult to achieve. With the values likely to be encountered the value of gain tolerated would not be so great. However, there are ways of compensating for lags in power amplifiers so that high gains can be used to improve response and accuracy without causing instability trouble.

Variable-Delivery Pump and Rotary Motor: To conclude this article characteristics of a servo in which the power drive consists of a variable-delivery pump supplying a rotary hydraulic displacement motor driving through a gear train will be investigated. Note that the system, Fig. 23, also includes an open-loop valve-cylinder relay.

Analysis of the relay is the same as that outlined earlier except that here it is assumed that λ_e is infinitely large (i.e., compressibility can be neglected since operating loads are fairly small), and that the cylinder load consists of a damping load as well as an inertia. In this case

$$F = m\frac{d^2x}{dt^2} + f\frac{dx}{dt} \tag{45}$$

That is

$$\xi(s) = ms^2 + fs \tag{46}$$

Since the relay is on open-loop its transfer function can be written

$$\frac{x}{y}(s) = \frac{K_2}{s(1 + T_2 s)} \tag{47}$$

where

$$K_2 = \frac{K_2' \lambda_e}{\lambda_e + K_2' f} \text{ and } T_2 = \frac{mK_2'}{\lambda_e + K_2' f}$$

An approximate expression for the transfer function of a power drive including a variable-delivery pump of the kind used here was developed earlier.[8] For an accurate dynamic analysis, however, it is necessary to make a more thorough investigation, similar to that already made in this article for a valve-cylinder relay. Indeed the transfer function which is finally obtained is very similar to that already derived for the relay. It is

$$\frac{\theta_o}{x}(s) = \frac{K_3}{s(1 + T_3 s + T_4^2 s)} \tag{48}$$

where

$$K_3 = \frac{rNv_n}{120\, L_p\, V_m} \; ; \; T_3 = \frac{Ir^2\, B}{\eta_m\, \eta_g\, V_m^2}$$

$$\text{and } T_4 = \frac{r}{V_m}\sqrt{\frac{\lambda V_c}{\eta_m\, \eta_g\, N}}$$

From the block diagram, Fig. 23*b*, it can be seen that the loop transfer function is

$$Y_o(s) = \frac{K_1\, K_2\, K_3}{s^2(1 + T_1 s)(1 + T_2 s)(1 + T_3 s + T_4^2 s^2)} \tag{49}$$

It is of particular interest to note that in this case the order of the servo is two. That is, the power of the s factor in the denominator is two. This follows from the fact that both the hydraulic relay and the power drive are in open-loop, although, of course, the complete loop is closed. There are said to be two integrations in the loop.

In many cases T_1 and T_4 may be negligible compared with the other time constants of the system. In this event Equation 49 simplifies to

$$Y_o(s) = \frac{K}{s^2(1 + T_2 s)(1 + T_3 s)} \tag{50}$$

where $K = K_1\, K_2\, K_3$. Then the overall transfer function of the servo will be

$$\frac{\theta_o}{\theta_i}(s) = Y_c(s) = \frac{K}{T_2\, T_3\, s^4 + (T_2 + T_3)s^3 + s^2 + K} \tag{51}$$

The system is inherently unstable since there is no term of s to the power one in the denominator. This is also shown by the Nyquist plot, Fig. 24*a*.

This tendency to instability is inherent in second and higher order systems. In order to stabilize them, and at the same time retain their zero velocity-error characteristic, it is necessary to modify the Nyquist plot, Fig. 24*b*. In order to achieve this stabilization it is necessary to modify the system by adding elements with special frequency-sensitive characteristics. Just how this may be achieved will be discussed in a future article.

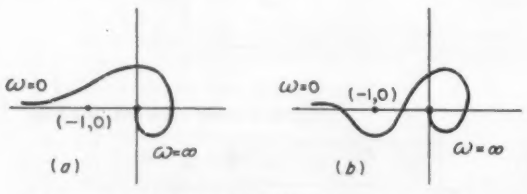


Fig. 24—Nyquist plots for the servomechanism shown in Fig. 23 show, *a*, that it is inherently unstable but can be modified, *b*, to become stable. This entails the use of special frequency-sensitive elements.

References

This article is the eleventh in a co-ordinated group by J. M. Nightingale on servo systems. The previous articles and the issues of MACHINE DESIGN in which they appeared are:

1. "Automatic Control Systems" ..... May 17, 1956
2. "Servo Mathematics" ..... June 28, 1956
3. "Evaluating Servo System Performance—Part 1" .. July 26, 1956
4. "Evaluating Servo System Performance—Part 2" .. Aug. 9, 1956
5. "Analyzing Servo Systems" ..... Nov. 1, 1956
6. "Hydraulic Servo Components—Part 1" ..... Nov. 29, 1956
7. "Hydraulic Servo Components—Part 2" ..... Dec. 13, 1956
8. "Hydraulic Servo Components—Part 3" ..... Dec. 27, 1956
9. "Hydraulic Servos—Part 1" ..... Feb. 21, 1957
10. "Hydraulic Servos—Part 2" ..... Mar. 7, 1957

Other helpful sources of information on points discussed in this article are:

11. R. Hadekel—"Hydraulic and Pneumatic Servos," *Automation*, October 1954 to March 1955.
12. N. F. Harpur—"Some Design Considerations of Hydraulic Servos of the Jack Type," *Proceedings of the Institution of Mechanical Engineers*, London, 1953.
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Charts for determining

CORNER ANGLES

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IN DESIGN there frequently arises the problem of constructing a box with a rectangular base having sloping sides. Determining the required corner angles by the cut-and-try method is out of the question. The necessary angles can be found with ruler, compass, protractor, and drafting board with considerable inconvenience.

When the sloping sides of a box with a rectangular base make angles θ and ϕ from the vertical, the corner angles α and β (Fig. 1*a*) required for a correct-fitting junction are given by

$$\tan(\pi - \alpha) = \frac{\cot \phi}{\cos \theta}$$

and

$$\tan(\pi - \beta) = \frac{\cot \theta}{\cos \phi}$$

The charts shown in Fig. 1, along with Table 1, are designed to provide a rapid graphical solution of these two formulas.

To use the charts, place a point vertically above the desired value of θ and horizontally opposite the desired value of ϕ. Read the required value of α by interpolating between the curved α lines. Likewise, read the necessary value of β by interpolating between the curved β lines.

The four quadrants of the chart in Fig. 1*b* are identical except for the angle labels. Consequently, all the necessary information can be obtained from just one quadrant if the angle labels are properly substituted. A detailed enlargement of the upper-right quadrant is shown in Fig. 1*c*. The higher accuracy afforded by this enlargement permits interpolation to about 20 minutes of arc.

Example: One side of a box is to lean inward 28 deg from the vertical ($\theta = -28$), and the adjacent side is to lean outward 10 deg from the vertical ($\phi = 10$). The problem is to find the corner angles, α and β, for the two sides.

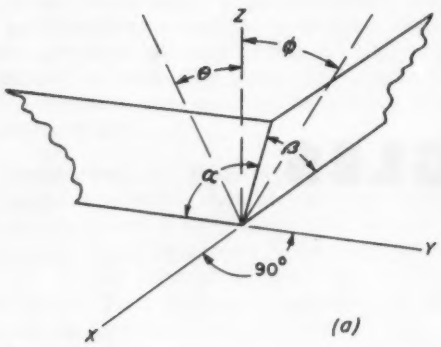
In Fig. 1*b*, at the intersection of $\theta = -28$ deg and $\phi = 10$ deg, approximate values are found to be $\alpha = 98$ deg and $\beta = 63$ deg. For greater accuracy, Fig. 1*c* should be used.

Adjustments for minus values of θ or ϕ, and for values of α or β less than 90 deg, can be made mentally, or the "conversions" given in Table 1 can be used. That is, for $\theta = -28$ and $\phi = 10$, the solution lies in the second quadrant. Therefore, from Table 1, $\theta' = -\theta = -(-28) = 28$, and $\phi' = +\phi = +(+10) = 10$. The answer at this intersection in Fig. 1*c* is $\alpha' = 99$ and $\beta' = 117.8$. Then, for the second quadrant, from Table 1, $\alpha' = +\alpha = 99$ deg. And $\beta' = 180 - \beta$ or $\beta = 180 - \beta' = 180 - 117.8 = 62.2$ deg.

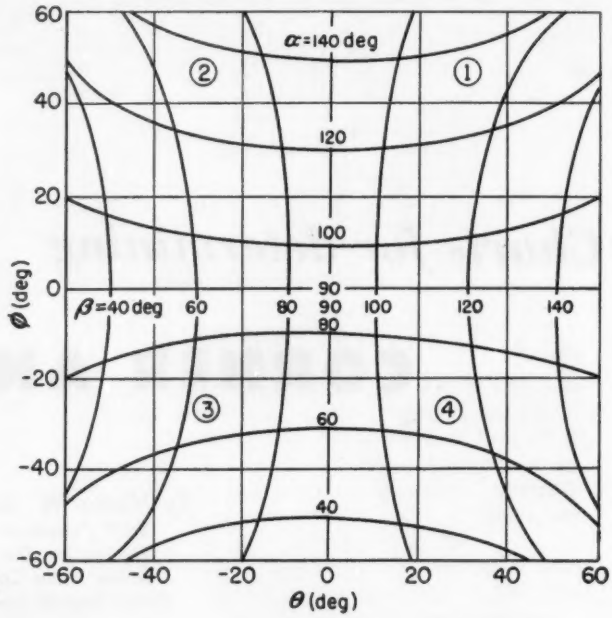
Table 1—Angle Conversions According to Quadrants

Fig. 1c Angles	Quadrant			
	First	Second	Third	Fourth
θ'	$+\theta$	$-\theta$	$-\theta$	$+\theta$
ϕ'	$+\phi$	$+\phi$	$-\phi$	$-\phi$
α'	$+\alpha$	$+\alpha$	$180-\alpha$	$180-\alpha$
β'	$+\beta$	$180-\beta$	$180-\beta$	$+\beta$

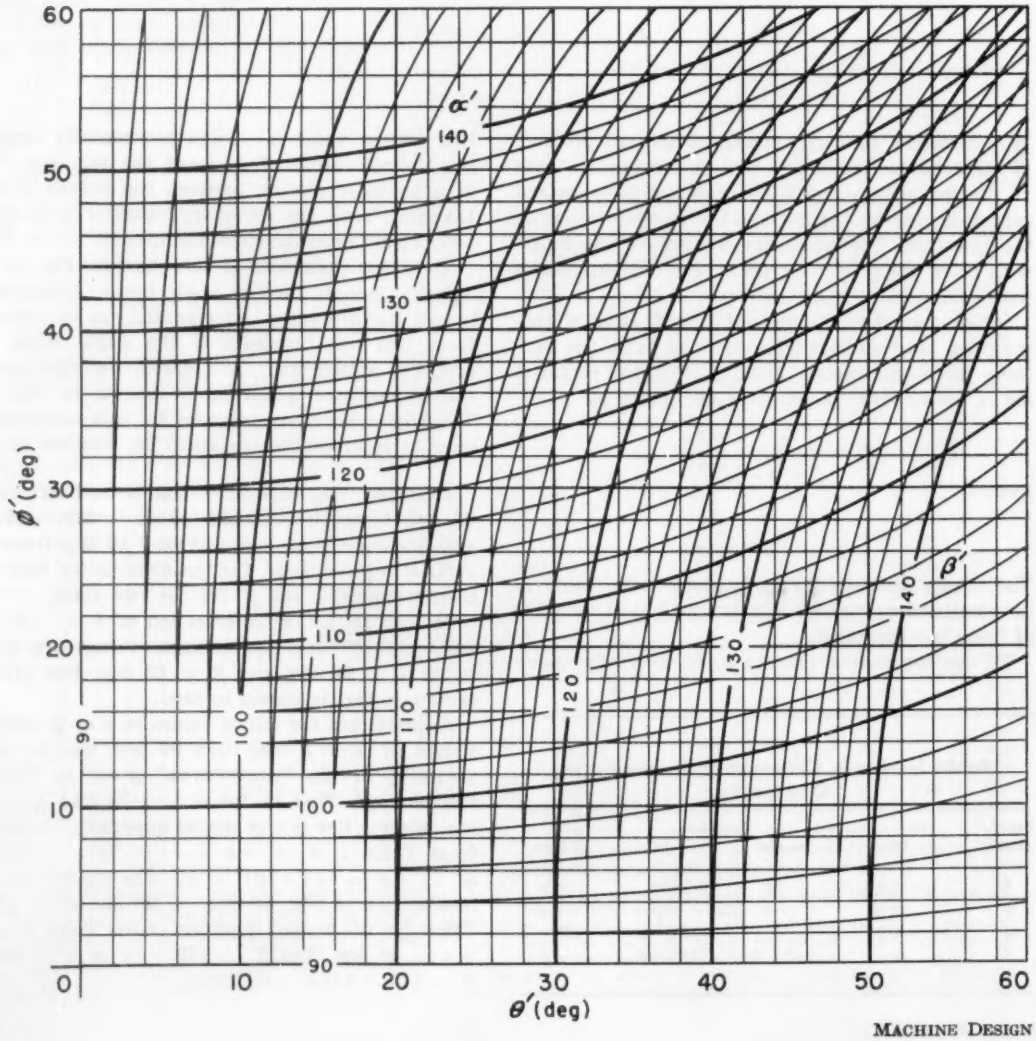
Fig. 1 — Nomenclature and charts for determining corner angles.



(c)



(b)



Application factors for

Titanium

- High strength
- Low weight
- Heat resistance
- Formability
- Corrosion resistance
- Welding

PURE titanium has singular mechanical properties. Alloys of titanium have strength properties equal to that of alloyed steel. Its specific weight is only 60 per cent that of steel, so its strength-weight ratio is outstanding. In addition, the corrosion behavior of titanium and its alloys is excellent. It surpasses stainless steel.

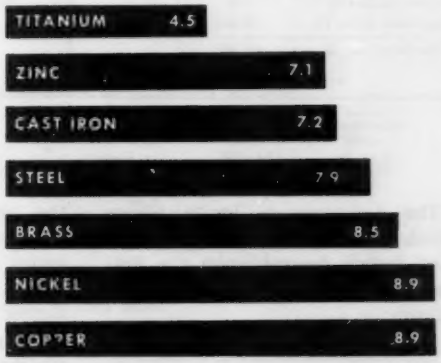
However, like every other material, it has certain deficiencies or disadvantages. For some applications titanium is the best possible material; for others it is wholly unsatisfactory. Disadvantages include its high affinity for oxygen, nitrogen, and carbon. The former two elements are soluble in the metal and when present in relatively high percentages, reduce ductility to zero. Also, when the thin oxide layer normally present on each piece of titanium is removed, the metal becomes very reactive, galling with other metals and with titanium, and reacting with the abrasive during grinding. When molten, titanium reacts with most known materials. The oxidation rate at the melting point is so high that inert atmospheres must be used. The engineer must realize and compensate for all these undesirable features.

The design notes presented here should be helpful in determining the adaptability of titanium to product application, and in designing titanium parts and assemblie .

From "Titanium Design Notes" in The Magazine of Magnesium, *published by Brooks & Perkins Inc., Detroit, November,* 1956.

Weight Reduction

Specific gravity of titanium is 4.5. Except for magnesium (1.8) and aluminum (2.8), titanium is the lightest weight commercial metal. Titanium may provide valuable weight saving when it can replace steel, stainless steel, copper, or nickel alloys.



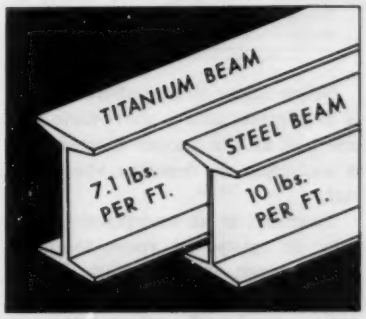
Specific gravities of typical metals.

Stiffness-to-Weight Ratio

Compared with steel, titanium has a high stiffness-to-weight ratio. Modulus of elasticity for titanium is 15 million psi; for steel 29 million.

Stiffness is resistance of a material to deflection under a given load within the elastic limit. The amount of such deflection is proportional to the moment of inertia of the beam multiplied by the elastic modulus of the material.

When a part previously made of steel is being redesigned for titanium, the moment of inertia must be increased in proportion to the lower elastic modulus of titanium to obtain the same stiffness.



Beams of equal stiffness. Relative stiffnesses in bending, based on rectangular beams of constant width and equal weight are: steel 1.0, titanium 2.7.

Strength-to-Weight Ratio

Figures given in the table near top of the next page are based on the use of rectangular beams of equal width but varying thickness. Under such conditions the strength of any material increases as the

square of the increase in thickness (depth of section).

In this table titanium alloys have been listed as 110, 120, 130, and 140 to indicate alloys with tensile yield strengths of 110,000, 120,000, 130,000, and 140,000 psi, respectively.

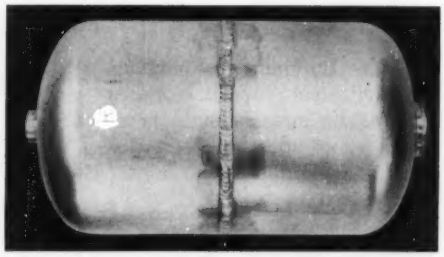
Relative Strength of Metals*

Material	Thickness Factor	Strength Factor
SAE 1025 steel	1.00	1.00
SAE 4130 steel	1.00	3.75
Aluminum 2024-T4	2.85	9.04
Aluminum 7075-T6	2.85	14.90
Titanium A55	1.75	4.20
Titanium 110	1.75	8.40
Titanium 120	1.75	9.16
Titanium 130	1.75	9.93
Titanium 140	1.75	10.60
Magnesium AZ31-O	4.39	8.31
Magnesium AZ31-H24	4.39	14.29
Magnesium ZK60A	4.39	15.80
Magnesium AZ80-T6	4.39	17.00

*Sections are of equal weight.

Welding Characteristics

Unalloyed titanium and some of the titanium alloys are readily welded by inert-gas shielded arc welding. With some of the alloys it is necessary to do the welding in a completely enclosed welding chamber with the work area completely enveloped in argon or helium gas. This prevents absorption of oxygen and nitrogen with consequent embrittlement of the weld. Sound, high-strength welds can be made if proper techniques are followed.



Pressurized titanium cylinder. Each half is hot drawn, and the two halves are welded together with a single circumferential weld. The cylinder was tested at 5000 psi pressure without distortion or damage.

Creep

The temperature limits above which creep becomes a predominant factor depend upon the material and are approximately as follows:

Material	Temperature (F)
Magnesium (AZ31A)	150
Aluminum	300
Iron	850
Stainless steel	1000
Cobalt	1300
Molybdenum	1600

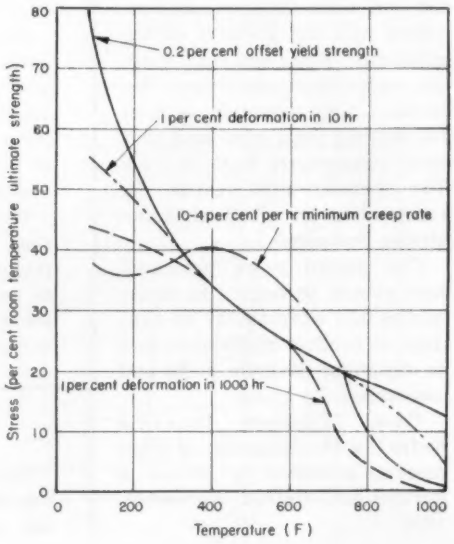
Below these temperatures, creep is negligible, and a short-time tensile test at the proper temperature is sufficient to describe the material.

Titanium is an exception to this rule; it creeps at room temperature but not at 400 to 600 F. This means titanium has two ranges (one extending from room temperature to approximately 300 F, and one above 600 F) where creep determines the maximum allowable stresses. Between approximately 400 and 600 F, however, the short-time tensile properties are sufficient to describe the engineering character of the material.

The graph gives the variation of strength properties with temperature for unalloyed titanium sheet. In the range 400 to 600 F, the yield strength is as low or lower than the plotted creep properties and is of greater importance in this range, whereas at higher or lower temperatures, creep properties (1 per cent deformation in 1000 hours) become the critical (lowest) values.

The lack of creep between 400 and 600 F is probably caused by strain aging of the material when deformed at slow rates. Because of the characteristics discussed, stress-rupture curves and design curves of titanium and titanium alloys are almost parallel to the time axis between 400 and 600 F (no second stage creep, all deformation takes place during loading), whereas at room temperature and at temperatures above 600 F second-stage creep takes place.

At elevated temperatures, titanium and titanium alloys take a position between the light met-



Effect of temperature on yield strength and creep properties of unalloyed titanium.

als and the creep-resistant steels in regard to creep behavior. For most present commercial alloys, 800 F is the upper limit of application; the commercial alloy A110 AT (5 per cent Al, 2.5 per cent Sn) and several experimental alloys offer, however, possibilities to extend this limit to approximately 1000 F.

Resistance to Fatigue

Fatigue strength usually depends upon these factors:

1. Tensile and yield strength of the material.
2. Microstructure.
3. Surface conditions.
4. Notches present and notch sensitivity of the material.
5. Corrosive environments.
6. Temperature.
7. Other factors (speed of testing, etc.).

Fatigue strength increases proportionally to the strength of the metal. The endurance ratio (endurance limit divided by tensile strength) is high for titanium (approximately 0.50). This means that titanium has basically good fatigue properties.

Surface conditions of the specimen usually have a great influence upon its fatigue strength. The most striking and highly important result of tests is the low fatigue strength of ground specimens.

Oxidized or nitrided surfaces also exhibit an appreciably reduced fatigue strength. Shot peening will increase the fatigue life in the high stress region, but does not have much influence upon the endurance limit.

On the other hand, rough machining produces approximately the same endurance limit as fine machining and hand polishing. Electrolytic polishing also produces the same values.

Titanium and titanium alloys are of medium notch sensitivity; notches and how they were made, therefore, play an important role. Again, grinding a notch is usually much more harmful than machining the same notch.

Corrosive environments, fortunately, have little or no influence upon the fatigue life of a titanium specimen. Unalloyed titanium exhibits an outstanding resistance to corrosion fatigue in salt water. Its fatigue strength under this condition is better than that of K-Monel metal or 16Cr-2Ni stainless steel.

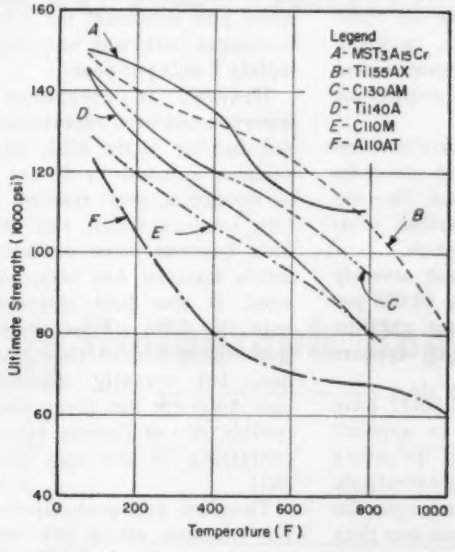
Fatigue Properties of Titanium Alloys*

Composition	Tensile Strength (1000 psi)	Endurance Limit (1000 psi)	Endurance Ratio
Unalloyed (A55)	95	62	0.65
Unalloyed (Ti 75A)	90.5	43.5	0.48
2.7 Cr, 1.3 Fe, O_2 (Ti 150A)	152	76	0.50
3.0 Cr, 1.5 Fe, O_2 (Ti 175A)	163	88	0.54
4 Al, 4 Mn (C130AM)	149	82	0.55
4 Al, 2.5 Sn (A110AT)	138	76	0.55

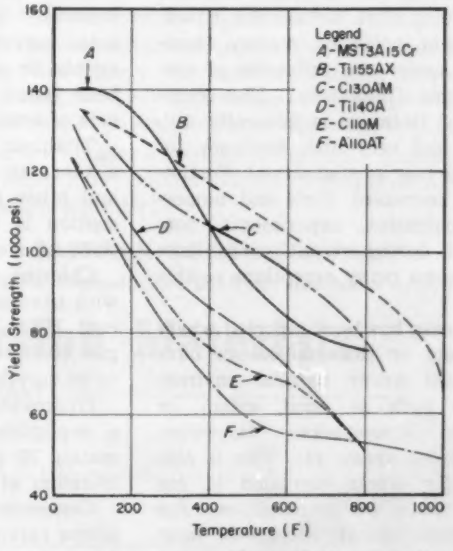
*Smooth machined samples, rotating beam.

Elevated-Temperature Tensile Properties

All titanium alloys show a sharp drop in tensile and yield strength with increasing temperature within the range 75 to 400 F. At somewhat higher temperatures (approximately 600 F) the strength vs temperature curves have generally a lower slope due to the tendency of titanium for strain aging.



Effect of temperature on tensile strength of commercial titanium alloys.



How temperature affects yield strength of commercial titanium alloys.

Formability

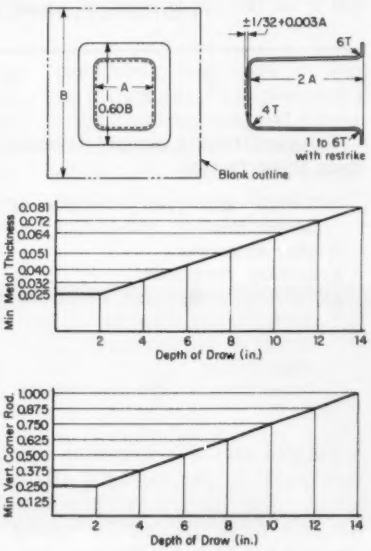
Titanium is formed by the same general method used for other metals, except that forming is done hot.

An advantage of hot forming is that much more complicated and more severe draws can be made than are possible in one operation with most other metals.

Springback is never a problem, and with hot single-draw operations no intermediate anneals are required. The diagrams show suggested design factors for deep-drawn unalloyed titanium parts.

Hot forming with the metal held at temperatures in the 1000-1350 F range for a short time (4 to 8 minutes) involves no hydrogen pick-up. On the other hand, there is real danger of hydrogen pick-up with resulting embrittlement when titanium is cold drawn and annealed following the draw. Hydrogen pick-up depends more upon time at temperature than upon the temperature to which the material is heated. Hot drawing with the short time-at-temperature is much safer than cold drawing with the long-time-at-temperature intermediate anneals.

Titanium alloys vary in their formability. In general, forming which can be done with most of the alloys is limited to less severe draws and forming than is possible with pure titanium. The suggested design factors should not be used for the alloys.



Sugested design factors for deep-drawn unalloyed titanium parts.

Corrosion Resistance

The high corrosion resistance of titanium and titanium alloys is considered as one of the primary assets of the new metal. A protective film of stable oxide is believed to be mainly responsible for the excellent corrosion resistance. Addition of oxidizing agents or air-aeration of the corrosive medium, therefore, often reduce the attack. Titanium polarizes readily, especially under the influence of certain ions (inhibitors). The corrosion of titanium is generally uniform, and very little tendency for pitting has been observed. Fortunately, increased work and numerous corrosion experiments conducted during recent years have not shown many exceptions to this rule.

No case has been reported where titanium or titanium alloys have corroded under natural environments such as rural, urban, or marine atmospheres, tidewater, salt water spray, etc. This is also true for stress corrosion of the metal under similar conditions. For dissimilar metal corrosion, however, some exceptions may occur.

The only inorganic acid which attacks titanium in all concentrations and for which no inhibitor as yet exists is hydrofluoric acid. This acid, therefore, is extensively used to pickle and etch the metal.

Sulfuric, phosphoric, and hydrochloric acids attack titanium in the higher concentration ranges, whereas the low concentrations are relatively harmless. For all three acids certain inhibitors, oxidizing agents, or anodizing processes have been found which will reduce the rate of attack.

Titanium also has excellent resistance to cold and hot chlorides and other salt solutions. One exception is hot concentrated solutions of aluminum chloride.

Chlorine gas will react severely with titanium when dry (0.005 per cent H_2O), whereas wet chlorine gas (0.013 per cent H_2O) appears to be harmless.

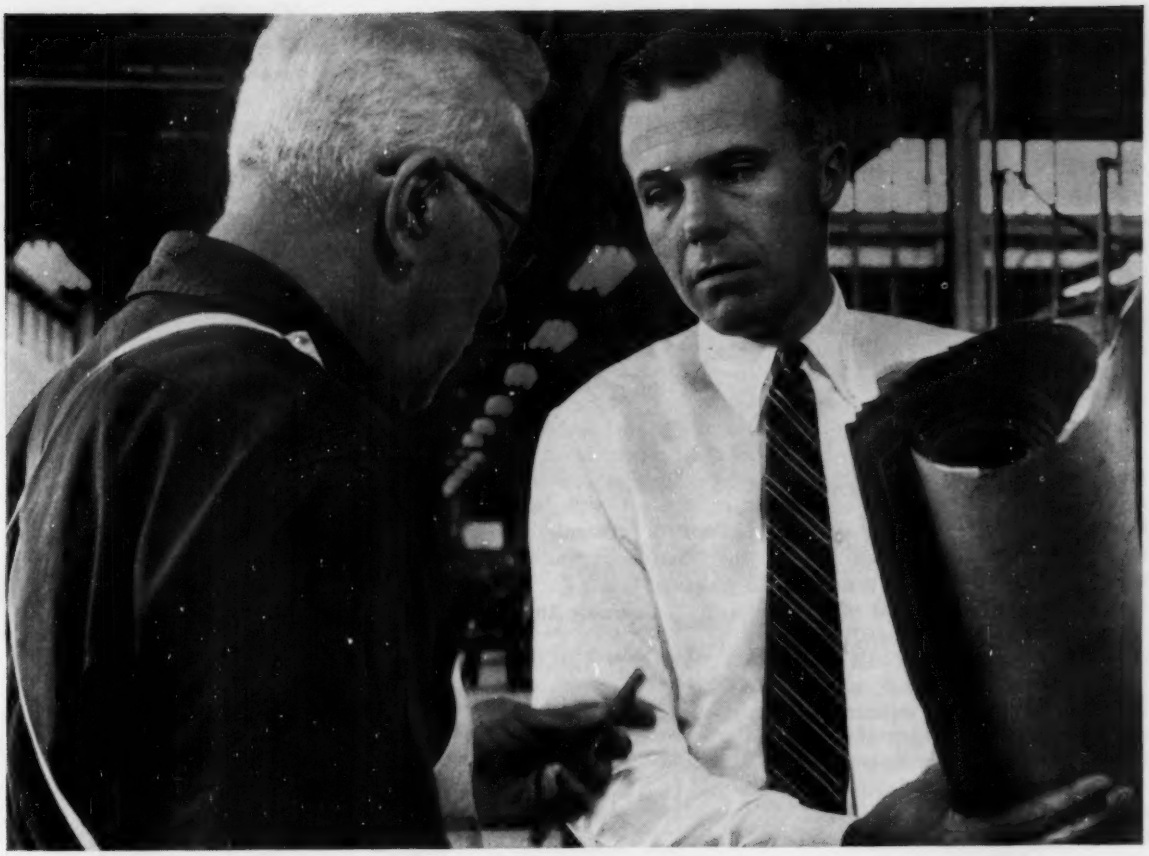
Hydroxides (hot and cold) have a negligible effect up to approximately 20 per cent, but do attack titanium at higher concentrations.

Generally, but not always, the alloys (alloying additions less than 10 per cent total) react quite similarly to the commercially pure material in corrosion behavior.

Due to the oxidizing action of the acid which builds up a protective oxide layer, titanium and titanium alloys are very resistant to nitric and white fuming nitric acid. The maximum rate of reaction has been observed at 100 C and with approximately 50 per cent nitric acid solutions; but even this maximum rate was only approximately 7 mils per year.

However, an unexpected phenomenon has been experienced with red fuming nitric acid; titanium samples exposed to it are liable to develop a very reactive corrosion product which can explode. This happens when sufficient reactive material has been accumulated. It was first believed that only RC 130A (8 per cent Mn) was susceptible to this phenomenon, but recently commercially pure titanium has given the same trouble in red fuming nitric acid containing 20 per cent dissolved NO_2.

Titanium and probably most of the titanium alloys are very resistant to many organic components such as acetic, lactic, tannic,



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tartaric acids, chlorinated hydrocarbons and most other related organic materials. The metal appears to be completely immune to common fruit and vegetable juices. Exceptions to this are: trichloracetic acid, all concentrations; formic acid, 25 to 90 per cent; oxalic acid, except low concentrated cold solutions; citric acid, at higher concentration (about 50 per cent), especially hot.

Titanium coupled with other structural metals behaves very similarly to stainless steel. The titanium part (which in most cases becomes electropositive) does not severely corrode, but the corrosion of the other metal may be increased by galvanic action. The table gives results of the penetration rates in mils per year of different metals when coupled with titanium in aerated 1N NaCl solution. The weight losses of the different materials were measured in mg per sq decimeter per day and converted into penetration per year (although it is realized that the attack would be somewhat localized) to give a better idea of the severeness of the attack.

As may be seen, magnesium coupled with titanium corrodes most of all the metals tested. This occurs not only in salt water but also in normal urban atmosphere. The titanium alloy Ti 150A (2.6 per cent Fe, 1.3 per cent Cr) behaves somewhat better than unalloyed titanium; the alloying elements probably favor passivation of the alloy. Besides magnesium, zinc and iron show a high galvanic penetration and even aluminum alloys corrode at a rate far above what is normally considered a low, desirable penetration rate (5 mils per year). Copper, brass and especially nickel and nickel-base alloys show very low galvanic corrosion when coupled with titanium.

In contact with aluminum, titanium is generally more noble than aluminum, and the latter is dissolved in an accelerated manner. Under certain conditions, titanium can become the electronegative metal of the couple, and in this case is slowly corroded. This condition was observed in 0.1-normal H_2SO_4 solutions. In 1N and 2N H_2SO_4, titanium (in contact with aluminum) was first electropositive and then electronegative after a certain time of operation; the final corrosion rates of the titanium were high.

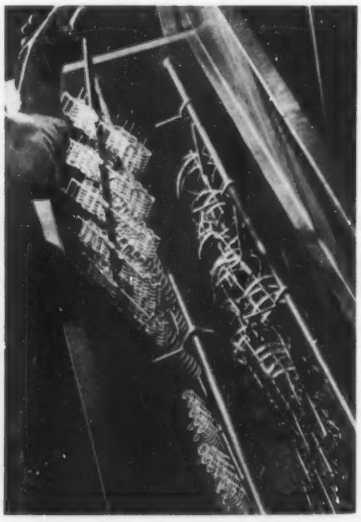
Fortunately, stress corrosion cracking of titanium in normal corrosive environments (such as urban and marine atmospheres, tidewater, salt spray, etc.) has not been observed. Stress corrosion of titanium has been found, however, in the presence of red fuming nitric acid.

Galvanic Attack of Various Metals in Aerated 1N NaCl

Metal	— Penetration (mils per year) when coupled with: — Titanium	Ti 150A (Fe-Cr)	Stainless Steel
Magnesium (AZ61-H24)	1240	212	2870
Zinc	58	40	71
Iron (SAE 4130)	55	..	62
Aluminum (7076-T6)	33	26	31
Aluminum (2024-T3)	29	18	31
Cadmium	18	15	15
Copper	12	5	8
Lead	11	16	13
Brass (60-40)	4	4	4
Nickel	0	0	3
Inconel	0	0	0

Types and characteristics of

Protective Coatings for Springs



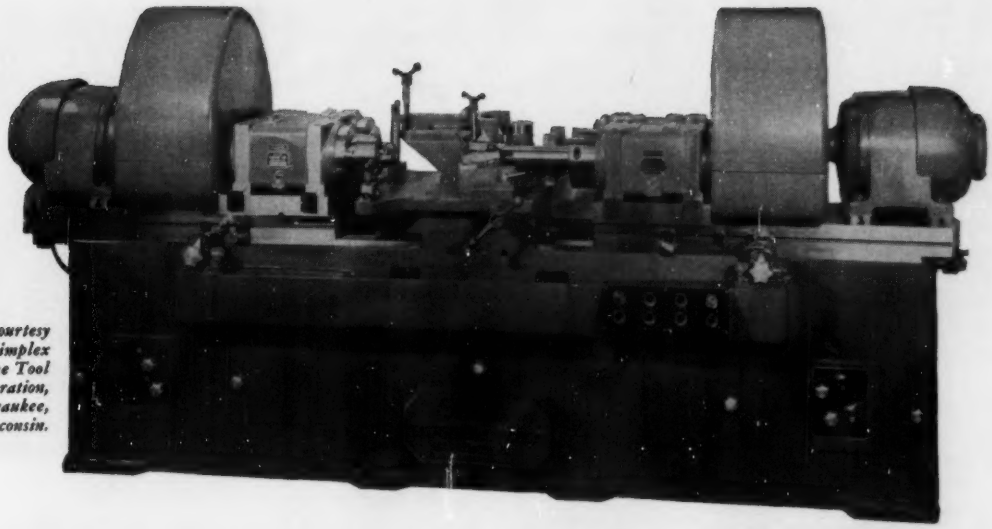
METALLIC coatings for springs offer the best rust protection and are generally considered to be the most decorative. Cadmium and zinc are perhaps the most often used and are the most economical of the electroplated finishes, Tables 1 and 2.

It will be noted that the letter "C" following the designated thickness of zinc denotes increased salt spray resistance due to an operation performed after plating known as a chromate treatment. The function of the chromate is to produce an oxide film on the plated surface. It also tends to give a higher luster to the finished product. The same is true of the cadmium plating. It is generally conceded that a cadmium plate will give higher resistance to salt spray than zinc.

Spring platers can turn cadmium into a variety of colors. The plated surface is immersed in a solution that forms a porous oxide. A penetrating and absorbent dye of the desired color is then applied. The definite advantages to this type of finish are identification and a very high salt spray resistance, similar to the chromate treatment.

A copper finish is useful in the identification of similar parts. It offers some rust protection and does not chip or peel under normal use. It is also used as an undercoat on nickel and chrome plate.

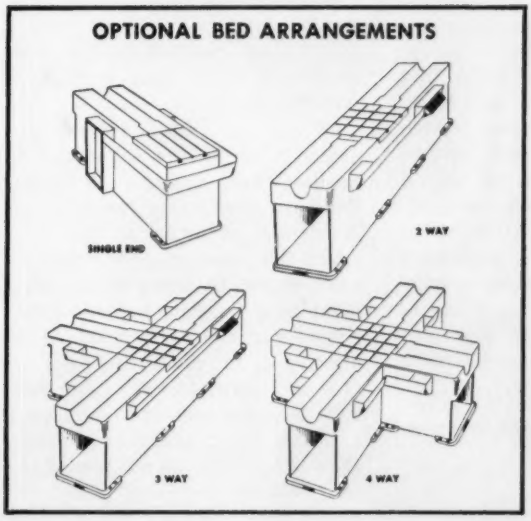
Chrome plating affords a lustrous finish often desired on bicycles, motorcycles or other exterior show parts. Its hard surface is utilized on flat springs to retard fretting



Photos courtesy of Simplex Machine Tool Corporation, Milwaukee, Wisconsin.

VERSATILITY FOR MACHINE TOOLS

Welded design does it at less cost



These precision boring machines can have one to four boring heads. The beds may vary in length . . . depending on the customers' needs. Such versatility in design and manufacture is made possible with welded steel . . . because:

- **A welded base design can be easily and quickly modified since there are no patterns involved.**
- **Less material is needed since steel is three times stronger than iron, 2½ times as rigid . . . yet costs a third as much per pound.**
- **Less machining, less finishing is needed.**

Basic advantages like these can be applied to many products. A Lincoln engineer who is backed by 45 years of Lincoln cost-cutting experience, will gladly show you how to benefit.

Write for Weldesign Bulletin, available to product designers.

THE LINCOLN ELECTRIC COMPANY

Dept. 1120 Cleveland 17, Ohio

The World's Largest Manufacturer of Arc Welding Equipment

When steel is three times stronger than iron

Has much more versatility

Yet costs much less

WHY aren't your products designed for welded steel?

Circle 489 on page 19

corrosion.

Nickel and tin give protection to spring materials where chemical reaction with gases and certain fluids is a factor.

Since metallic coatings are electrodeposited and hydrogen is emitted during the plating cycle, it is essential to heat the plated spring material to prevent hydrogen embrittlement. Research on the stress relieving of plated springs has shown they should be heated within two hours after plating. A typical stress-relieving temperature on cadmium or zinc would be 375 F for 3 hours. A higher temperature, say 425 F, will discolor the plating slightly and assure the consumer that the springs have been stress relieved. Hydrogen embrittlement, which has been a problem of high-carbon spring materials, is practically nonexistent in modern spring-plating shops that use approved methods of cleaning.

Preplated wire is available for use where tangling in a regular plating bath would be a source of trouble. Preplated wire is generally available with cadmium, zinc or tin. It will give a 24-hour salt spray resistance in a 20 per cent salt solution in most sizes except for the exposed cut-off ends.

Nonmetallic coatings, such as phosphate, are also put to good use on springs since they are not as susceptible to hydrogen embrittlement as most of the metallic coatings. Phosphate coatings are used in two different ways: As an undercoat or bond for paint, and with a coating of wax or oil. As an undercoat for paint, they provide a thin, porous film that enables more paint to cling to the spring surface without chipping or peeling. When used with a coating of wax, lacquer or oil, the phosphate coating will give a certain amount of salt spray protection at a relatively low cost. It is also useful on flat spring material as a lubricated surface which will retain an oil film.

Black oxide coatings, while not offering much resistance to salt spray, give steel a satin black finish often desired on guns or similar parts where sun reflection is undesirable. A coating of oil will greatly increase its ability to withstand corrosion.

A typical specification for phosphate and black oxide coatings is given in Table 3.

Of all the types of coatings available for springs, the most economical and colorful is paint. Paint not only makes identification of similar parts easier, but also offers fair resistance to corrosion. Care should be taken in selecting paint as a finish, especially where hot oil might have the tendency to dissolve it or cause the color to fade and make identification difficult. Another consideration is that a brittle paint might break from the surface that has not been phosphate-coated and clog some minute orifice. Painting flat surfaces is sometimes difficult since the paint will not adhere to burred edges. This will decrease the salt spray resistance.

The use of dyes applied directly to the surface of spring steel is somewhat limited because of their poor hiding characteristics. They are useful in hot oil or where a build-up of paint is not desirable. New dyes have been introduced to the market recently that have improved hiding qualities.

From "Protective Coatings for Springs" in The Mainspring, *published by Associated Spring Corp., August,* 1956.

Table 1—Typical Specification for Zinc Coating*

Class	Minimum Thickness (in.)	Salt Spray Resistance—White Salts (hr)	Salt Spray Resistance—Red Rust (hr)
GS	0.001	..	72
LS	0.0005	..	48
RS	0.00015	..	24
GSC	0.001	24	96
LSC	0.0005	24	72
RSC	0.00015	24	48

*U.S. Army Spec. 57-0-2C.

Table 2—Typical Specification for Cadmium Plating*

Class	Thickness (in.)	Salt Spray Resistance—White Salts (hr)	Salt Spray Resistance—Rust (hr)
Type 1—Without supplementary chromate treatment			
A	0.0005	..	240
B	0.0003	..	192
C	0.0002	..	96
Type 2—With supplementary chromate treatment			
A	0.0005	96	336
B	0.0003	96	288
C	0.0002	96	192

*Federal Spec. No. QQ-P-416.

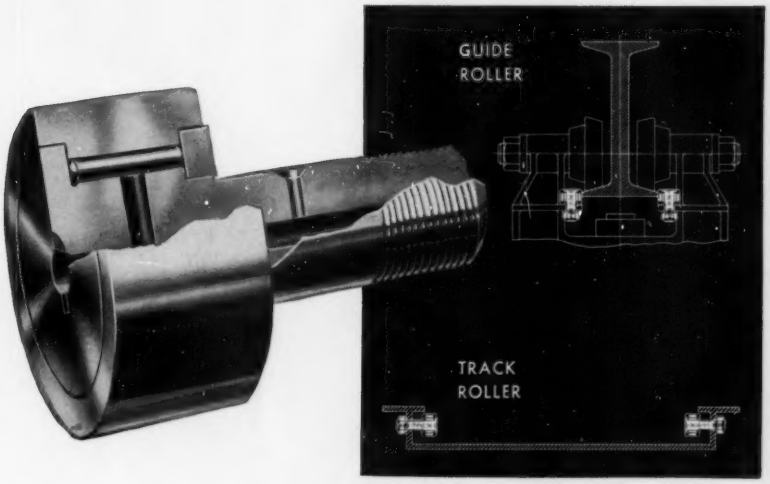
Table 3—Typical Specification for Phosphate and Black Oxide Coatings*

Classification	Salt Spray Resistance—Before Applying Finish (hr)	Salt Spray Resistance—After Applying Finish (hr)
Type 2—Phosphate coatings		
Class A—Finished with nondrying petroleum oils containing corrosion inhibitors suitable for use on sliding or bearing surfaces	1	24
Class B—Finished with a rust preventive suitably reduced for application and containing corrosion inhibitors	2	36
Class C—Suitable for finishing with paint products	No test	150†
Type 3—Black oxide coatings (excluding paint products)		
Class A—Alkali oxidizing process		
Grade 1—Finished with nondrying petroleum oils	½	2
Grade 2—Finished with rust-inhibiting lacquer	½	16
Grade 3—Finished with synthetic resin coatings	½	24
Class B—Chromate	½	24
Class C—Fused salts	½	24

*U.S. Army Spec. 57-0-2C. †Applies only to springs without sharp corners. Two coats of zinc chromate primer, for instance, will normally give a 72-hr salt spray resistance.

BEARING TIPS by McGill

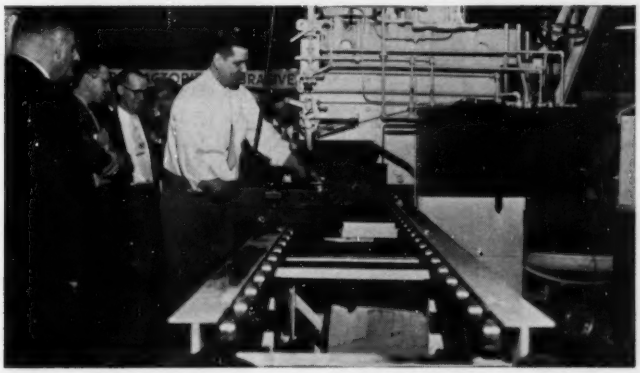
Let a CAMROL TRADE MARK bearing be your guide



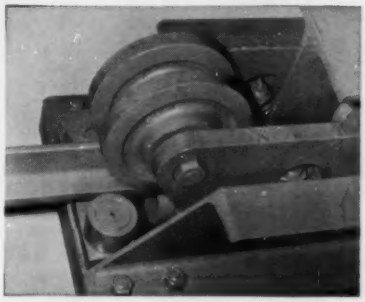
Obtain freer rolling, improved alignment and positive side thrust

In guide and support roller applications CAMROL Cam Followers insure free rolling action and positive side thrust while eliminating the wear of more costly flanged wheels. Then, too, they provide improved alignment and low starting and running friction with high unit load and shock capacity, especially at low speeds as track rollers. Lubrication is simplified and maintenance can be reduced to a minimum in these applications. Specify the interchangeable sealed SGR series for added protection against contamination.

CAMROL TRADE MARK CF bearings provide friction-free track rollers for automatic mold blower



McGill CAMROL CF rollers are used as guide rollers to form a mold conveyor in the Beardsley & Piper MBS-20 Mold Blower. The machine blows and squeezes cope or drag in a single automatic operation, handling up to 4 molds per minute. The CAMROL CF bearings replaced less efficient friction rollers in this application. Although, the duty here is rather light and speeds slow, the cam follower bearing provides lesser starting and running friction. This helps speed the flow of work from the machine, which must be fast and automatic. The integral stud feature eases assembly and its standard design simplifies procurement.



CF bearings minimize maintenance as crane side guide rollers

McGill CF cam follower bearings serve as side guide rollers in overhead cranes manufactured by Louden Machinery Company of Fairfield, Iowa. Freedom from maintenance, a time saver because of the inaccessibility of the bearing when the crane is in operation, is an important advantage of the cam follower bearing.

Send for Catalog No. 52-A

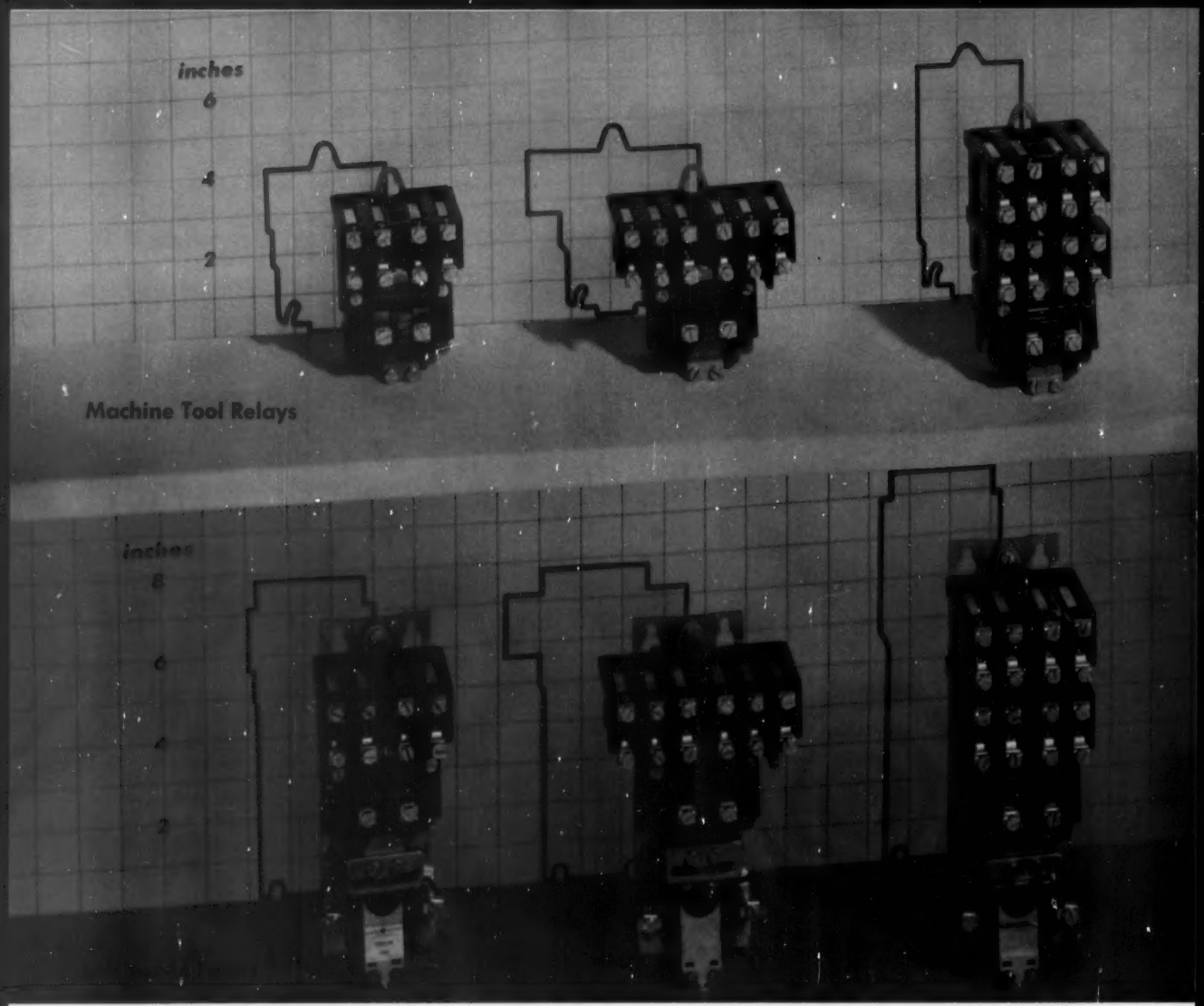
Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Circle 490 on page 19

Circle 491 on page 19→



LESS SPACE, MORE FLEXIBILITY, WITH GENERAL ELECTRIC'S–

New Machine Tool and Pneumatic Time-

Machine Tool Relays Require Minimum Mounting Space

General Electric's new relays provide the installation features and long life required by the machine tool industry.

MINIMUM MOUNTING SPACE is required for all the relays—2- through 12-poles. New 6-pole-in-line and 12-pole forms have the same mounting dimensions as the 4- and 8-pole forms respectively.

INSTALLATION and wiring is performed from the front, allowing relays to be mounted close together. The captive clamp-type terminals can be wired from four directions. In addition, contacts can be changed from normally-open to normally-closed without extra parts.

RATING is 10 amps, 600 volts maximum, a-c. Latched-in forms are also available.

Pneumatic Time-Delay Relays Provide High Repetitive Accuracy

The new General Electric pneumatic time-delay relay was designed for applications which require a reliable and accurate time-delay device.

FLEXIBILITY of pneumatic time-delay relay design allows the relays to be supplied with either one or two instantaneous auxiliary contact units, and one or two time-delay contact units. The timing head is available separately for use with Size 0 through 4 contactors and Size 1 through 4 magnetic starters.

HIGH CONTACT RATING of 25 amps "make and carry" at 600 volts maximum means that supplementary relays can often be eliminated. In addition, pneumatic timers can be front mounted and wired for further space savings.

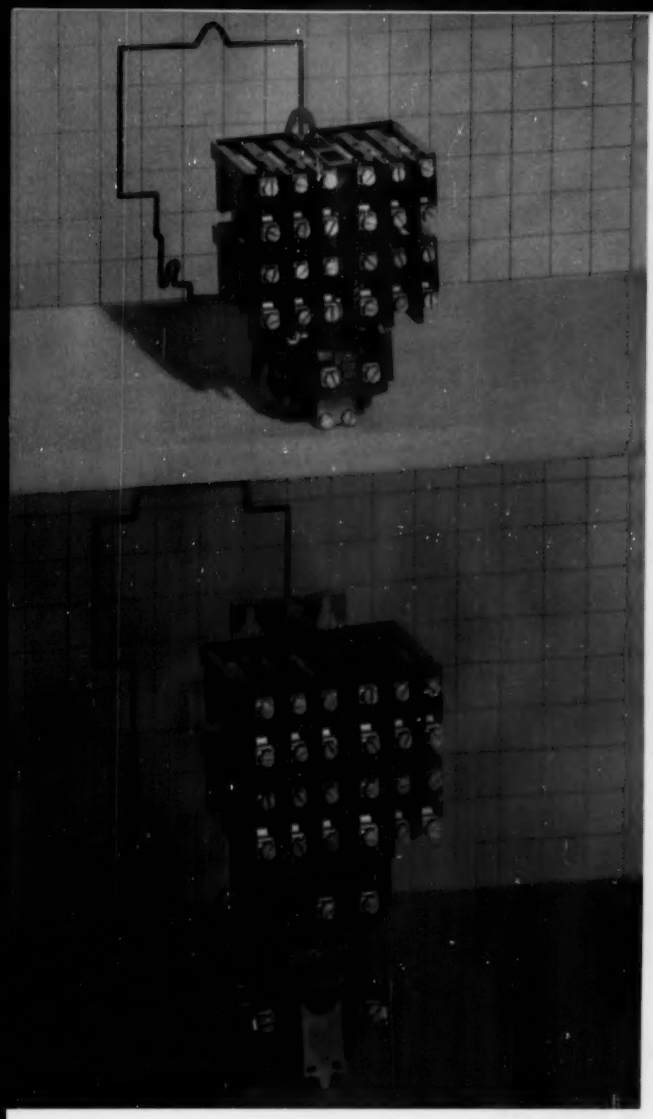
ADJUSTABLE TIME-DELAY permits the timer to be set for any time-delay interval from 0.2 to 180 seconds. Repetitive accuracy is ± 10%, and is not affected by atmospheric conditions. Adjustment is made by a simple screwdriver setting on the front of the unit.

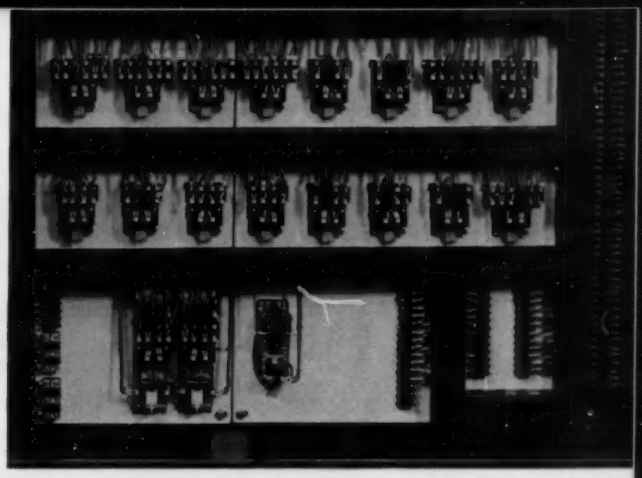
DEPENDABILITY results from many built-in protective features. A special filter mounted in a vertical position in the rear keeps dust and dirt out of the air port. Also, rigid cast construction prevents misalignment.

Relays Used on Pan-A-trol* Panels

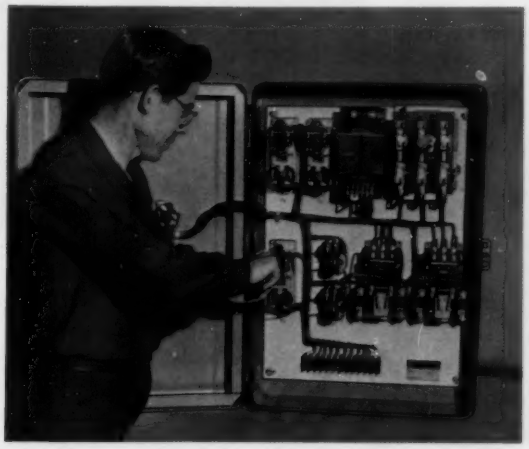
Using machine tool relays, pneumatic time-delay relays, and other standard control devices, G-E engineers build Pan-A-trol packaged control panels to meet your requirements and specifica-

*Trade-mark of General Electric Company





G-E RELAYS permit neat panel mounting arrangement. If desired, relays and wiring troughs may be mounted closer.



PAN-A-TROL PANELS utilize standard components like the new G-E relays, and are factory assembled and wired.

PNEUMATIC TIME-DELAY RELAYS can be modified easily with kits. Also, the timing heads are available separately.

Delay Relays

tions. These panels are completely assembled and wired at the factory; only external connections to the machine need be made. Pan-A-trol panels represent another offering by General Electric to simplify the work of design engineers.

Your nearest G-E Apparatus Sales Office can give you complete details on General Electric control devices and on the Pan-A-trol program. If you'd like reference material, write Advertising Section 731-11, General Electric Company, Bloomington, Illinois, and ask for:

GEC-1415 and 1416—Machine Tool Relays
GEC-1425—Pneumatic time-delay Relays
GEA-6334—Pan-A-trol panels

GENERAL ELECTRIC

7 *ways to better whiteprints...*

on the new printmaster 810

Here's the brand new Printmaster 810—with 7 big new operating features. They make your printmaking easier, more fool-proof than ever before!

1. New air flow system for better print pickoff
2. New diaphragm ammonia pump for top uniformity in developing
3. New cartridge heater for greatly improved development at high speeds
4. New phenolic "fingers" to pick off tracings without tearing
5. New protection sheet and suction baffles to keep originals safe
6. New feeder brushes to flatten curl in rolled tracings
7. New tracing receiving system to handle cut sheets and rolled tracings, both!

And that's not all. Incorporated into the "810" are such *proven* Ozalid advances as the electronic drive . . . low temperature cooling system . . . exclusive blower-timer and U/L approved safety devices. *Why not test run your own tracings through the new "810"? Simply call your local Ozalid representative. His number's in the phone book, or write: Ozalid, Dept. GG-3, Johnson City, N. Y.*

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OZALID®

First name in whiteprinting

Circle 492 on page 19

HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Dripproof & Enclosed Motors

Production testing techniques and construction features of Tri/Clad 55 motors in 1 to 5 hp dripproof and enclosed types are illustrated in bulletin GEA-5980. Servicing and installation advantages are also discussed. 12 pages. General Electric Co.

Circle 681 on page 19

Potentiometer Recorders

Specifications of easy-to-read Wheelco multipoint potentiometer recorders are given in bulletin F-7955. Instrument can be used to record up to 16 points on a single chart, using various sensing elements which provide an electrical signal corresponding to the measured variable. 2 pages. Barber-Colman Co., Wheelco Instruments Div.

Circle 682 on page 19

Motorized Pumps

Performance, design and application data on a line of Motor-Mount centrifugal pumps are given in illustrated bulletin 4200. Designed for use in manufacturing, chemical, paper and other industries as well as integral parts of machinery, pumps are available in sizes to deliver up to 1200 gpm at heads to 220 ft. 8 pages, Deming Co.

Circle 683 on page 19

Miniature Bearings

Capsule descriptions of a complete line of miniature ball and roller bearings for use in precision equipment are contained in illustrated catalog. Types described include radial, pivot, roller and special bearings in open and sealed designs. Tolerances, internal clearances, load capacity calculations, speed limitations and other technical data are included. 16 pages. Landis & Gyr, Inc.

Circle 684 on page 19

Processing Stainless Steel

Facilities and skills available to the user of parts fabricated from stainless steel, titanium and special alloys are described in illustrated bulletin SD-24. Entitled "Experimental and Production Brazing and Processing of Stainless Steel," booklet shows typical work that can be produced to customers' requirements. 4 pages. Wall Colmonoy Corp., Stainless Processing Div.

Circle 685 on page 19

Die-Cut Tapes

Uses and applications for printed and die-cut pressure-sensitive tapes are subject of folder 1265. It demonstrates how printed tapes are used as labels and nameplates on all types of products. Die-Cut tapes can be used to mask or protect odd-patterned surfaces. Tapes are also used as fabricating means. 6 pages. Minnesota Mining & Mfg. Co.

Circle 686 on page 19

Lubrication in Packaging

"How Automatic Lubrication Cuts Packaging Costs" is title of bulletin E-6 which discusses seven typical installations in various packaging and process industries. Lubricators and precision metering units are described. Bijur Lubricating Corp.

Circle 687 on page 19

Silicone Rubber

Five new heat resistant silicone compounds with Shore A hardness of 40 through 80 for service temperatures to 500° F are among the complete line of silicone rubber compounds offered in illustrated brochure "Acushnet Silicone Compounds." Also described are services and facilities available for producing parts molded to customer requirements. 12 pages. Acushnet Process Co.

Circle 688 on page 19

Wire Rope

The proper wire rope specification for use in all types of construction equipment is given in bulletin 5702. Also discussed are Lang Lay versus regular lay, rope constructions and the proper wire rope to use for clamshell bucket operation. 8 pages. Macwhyte Co.

Circle 689 on page 19

Fan-Cooled Motors

Totally-enclosed rerated fan cooled motors with ratings from ½ to 40 hp are described in detail in bulletin 500-A. Complete dimensions of old NEMA frames and new rerated frames are tabulated. 4 pages. Robbins & Myers, Inc.

Circle 690 on page 19

Bushed Roller Chain

Features of LXS bushed roller chain are detailed in book No. 2454. Chains are available with straight or offset sidebars, and with small or large rollers for a variety of conveyor and power transmission applications. Pitches range from 1.5 to 6 in. and ultimate strengths to 280,000 lb. 16 pages. Link-Belt Co.

Circle 691 on page 19

Motor Stator Wedges

Dimensions of each of eight sizes of U-wedges for stator windings of class B electric motors are listed in bulletin D 11-30-56. These one-piece wedges are made of glass fiber reinforced polyester in widths from 3/16 to ½-in. 2 pages. Glastic Corp.

Circle 692 on page 19

Bronze Valves

Physical characteristics and application information on a line of solder end and silver-braze end bronze valves in gate, globe and check designs are presented in illustrated bulletin DH-25. They are usable for a wide range of fluid services. 4 pages. American Chain & Cable Co., R-P&C Valve Div.

Circle 693 on page 19

Filler for Plastics

"Moly-Sulfide as a Filler" is title of bulletin Lu-12 which describes the uses of molybdenum disulfide as a filler in nylon, phenolic laminates, Teflon and other plastics; natural and synthetic rubber; and asbestos. Material imparts improved friction and mechanical properties. 4 pages. Climax Molybdenum Co.

Circle 694 on page 19

Sealing Rings

Engineering data aids in design of equipment to utilize Quad Ring seals. These seals for packing glands are available in diameters from ¼ to 10¼ in. Tables give design factors. 2 pages. Minnesota Rubber & Gasket Co.

Circle 695 on page 19

Encapsulation Techniques

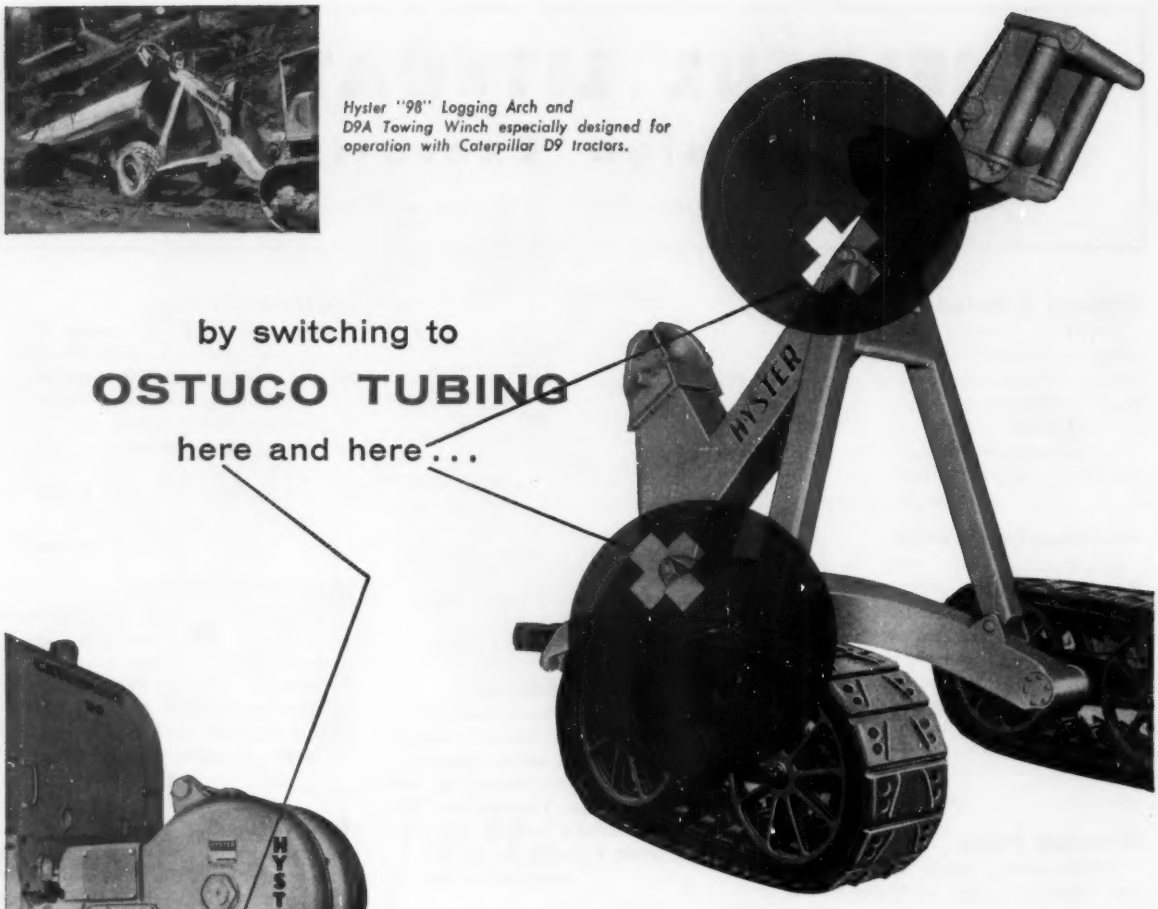
Information to aid engineers in the design of epoxy resin encapsulation

Hyster "98" Logging Arch and D9A Towing Winch especially designed for operation with Caterpillar D9 tractors.

by switching to

OSTUCO TUBING

here and here...



Hyster Company Makes Double-Cut on Costs!

Hyster Company, Portland, Oregon, out to beat machining costs of components in their logging arches and winches and a drawbar bracket, turned the trick by switching from another material to OSTUCO Seamless Steel Tubing.

Drawbar Bracket—Use of OSTUCO Tubing cut material and machining costs from $120,500 to $81,820 annually for a reduction of 32%.

Logging Arch—Used as sleeves in the Hyster "98" Arch, OSTUCO Tubing reduced material and manpower costs 10% annually.

In addition, Hyster engineers report the equipment is stronger and better able to take the strain of heavy hauling and winching jobs over rough logging terrain.

Perhaps you have hidden profit-robbers in your product. Better contact OHIO SEAMLESS for recommendations ... without obligation on your part, of course.

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processes and systems is presented in technical bulletin 18. It also describes physical and electrical properties of the Sonite series of filled epoxy resins for room temperature encapsulation of electrical and electronic components. 2 pages. Smooth-On Mfg. Co.

Circle 696 on page 19

Hydraulic Check Valve

Suitable for hydraulic service at 3000 psi, the AN-approved type MS ½-in. lightweight check valve as well as ¼ to 1-in. Tactair 1800 check valves are described in illustrated data sheet. 2 pages. Aircraft Products Co., Tactair Valve Div.

Circle 697 on page 19

Corrosion Resistant Treatment

"Corrosion Resistance of Chromallized Iron and Steel Parts" is a technical bulletin which cites the results of test runs and shows typical applications of this process for protecting parts. Process diffuses chromium into the surface of steel parts to provide corrosion and wear resistance. 8 pages. Chromalloy Corp.

Circle 698 on page 19

Wear Resistant Carbide

Characteristics of Kennametal Grade K501, a tungsten carbide with a platinum binder for severe corrosion conditions, are presented in bulletin L-501. Typical uses, workability, physical properties and chemical properties are given. 2 pages. Kennametal Inc.

Circle 699 on page 19

Metal Forming Process

Flotrusion process for cold flowing various metals into tubular forms of all sizes and shapes is detailed in illustrated folder "Why Machine It?" Process increases material strength, makes possible difficult designs and produces fine surface finishes. 6 pages. Claude C. Slate Co.

Circle 700 on page 19

Stocked Electric Motors

Various types of electric motors carried in stock are listed in the Baldor stock list. Brought up to date periodically, it gives quantity available, Baldor and NEMA frame, horsepower, voltage, phase, cycle, rpm's and catalog number. Baldor Electric Co.

Circle 701 on page 19

Oil-Hydraulic Equipment

High horsepower, oil-hydraulic pumps, motors and transmissions with ratings from 28 to 2300 gpm, 50 to 4000 hp and pressures from 0 to 3000 psi are detailed in engineering catalog 200. Heavy duty axial-piston pumps and motors are described. 18 pages. Vickers Inc., Waterbury Tool Div.

Circle 702 on page 19

Welding Electrodes

Information on AWS-ASTM arc welding electrode specifications, how to estimate electrode consumption, summary of welding symbols, factors in selecting electrodes and other interesting data are found in Electrode Data Book NH-504. 24 pages. National Cylinder Gas Co.

Circle 703 on page 19

Electrical Insulation

Properties, characteristics and uses of Armite, a vulcanized fiber electrical insulation in 0.004 to ⅛-in. thicknesses, and Spauldo insulation, made from rag stock and from 0.007 to 3/64-in. thick, are included in illustrated bulletin. 4 pages. Spaulding Fibre Co.

Circle 704 on page 19

Temperature Instruments

"Temperature Indicators, Detectors and Controls for the Aircraft Industry" is title of comprehensive catalog 56A. Sections deal with fire and overheat detectors, heater controls, accessory temperature controls, testing and calibrating equipment, gas turbine thermocouples and other temperature devices for use in aircraft. 38 pages. Fenwal Inc., Aviation Products Div.

Circle 705 on page 19

Fractional HP Motors

Series wound universal, capacitor three and four-lead, split-phase, shaded-pole and three-phase fractional horsepower motors and reducer motors are detailed in illustrated catalog. Ratings are from 1/1000-hp upward. Specifications, construction and dimensional diagrams are included. 12 pages. Bodine Electric Co.

Circle 706 on page 19

Magnetic Tape System

Stress, pressure, temperature and vibration can be recorded on Datatape magnetic tape recording and playback system, subject of illustrated bulletin 1561 B. Detailed specifications and application data are inclued. 24 pages. Consolidated Electrodynamics Corp.

Circle 707 on page 19

Combustion Instruments

Equipment for a complete combustion installation, including automatic draft control instruments and actuators; solenoid, diaphragm and motor operated valves for oil, gas, steam and water; time switches; relays; and oil burner primary controls, are content of illustrated catalog. General Controls Co.

Circle 708 on page 19

Leak Test Fittings

Fabricated tubing on any type of industrial fabrication can be tested for leaks with Sealastic fittings, described in illustrated catalog 209. How-to-use data are given, along with information on various types available. 4 pages. Chicago Forging & Mfg. Co.

Circle 709 on page 19

Tube Fittings

Line of Triple-lok tube fittings of brass, steel, stainless steel and aluminum is presented in illustrated catalog 4310. Included are swivel nut type and straight threaded fittings with O-rings for new SAE straight thread boss. 52 pages. Parker Appliance Co., Tube & Hose Fittings Div.

Circle 710 on page 19

Automatic Lubricators

Service instructions for the type N cyclic automatic lubricator are contained in illustrated instruction sheet. Sixteen types, all driven by machines they service, are covered. Specifications are given. 2 pages. Bijur Lubricating Corp.

Circle 711 on page 19

Resistance Welding Equipment

Line of Ampco-Weld resistanee welding electrodes and accessories is subject of illustrated catalog. Applications, specifications and dimensions of standard welding tips, wheels, dies and holders are given, along with data on various accessories. 28 pages. Ampco Metal, Inc.

Circle 712 on page 19

Ball Bearing Pumps

Model CK ball bearings pumps for hydraulic, coolant, transfer and circulating services are built in capacities from 5 to 200 gpm with pressures up to 400 psi. They are described and illustrated in bulletin 103 which gives their specifications and performance data. 8 pages. Tuthill Pump Co.

Circle 713 on page 19

Stainless Steel Tubing

Technical data on Croloy 27-4-1 type 329 low nickel seamless stainless steel tubing and Croloy 25-12 austenitic steel are contained in Alloy

SLIP RING ASSEMBLIES • BRUSH ASSEMBLIES • BRUSHES

CONTACTS . . . *one or all*

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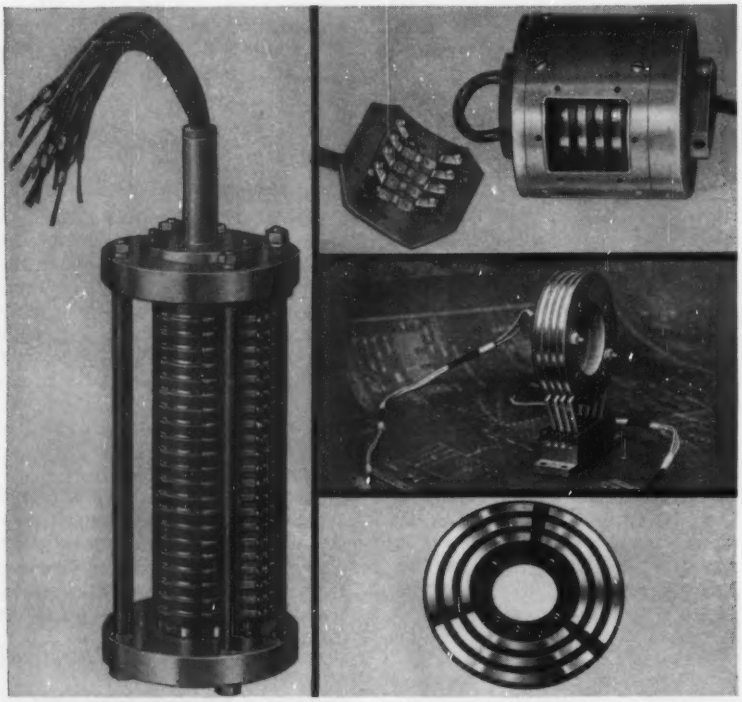
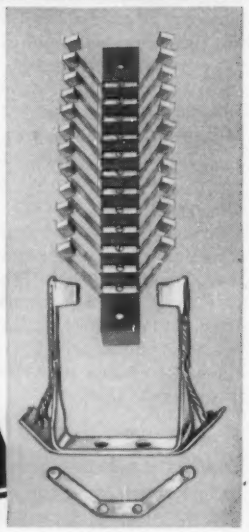


Superior Assemblies Have Brushes and Contacts Made by Superior

Seen above are several jobs which have solved problems for the manufacturers of end products. Sometimes we build a slip ring assembly which follows the customer's design, or we will design and build an assembly which suits your equipment. Practically any size or design can be met. Let us quote you on a complete Superior package unit including rings, brush holders, brushes and contacts of our own manufacture.

SUPERIOR CARBON PRODUCTS, INC.
9115 GEORGE AVENUE • CLEVELAND 5, OHIO



SCP SUPERIOR CARBON BRUSHES "Since 1919"

Circle 494 on page 19

Helpful Literature

Sales Letters 285 and 286. Corrosion resistance, chemical analysis, size range, mechanical properties, microstructure, welding characteristics and other data are covered. 3 and 4 pages. Babcock & Wilcox Co., Tubular Products Div.

Circle 714 on page 19

Thermostat

Direct-acting control that protects laboratory and industrial electrical equipment from exceeding preselected temperature limits is described in illustrated bulletin RT-809. Ranges up to 800° F are offered. Specifications are given. 4 pages. Robertshaw-Fulton Controls Co.

Circle 715 on page 19

Protective Coatings

Color tones for walls, ceilings and trim that complement and soften working light are featured in Optonic System of color selection. Color chart shows chips of many colors offered in variety of masonry, interior wall, floor, and other maintenance coatings. 4 pages. Arco Co.

Circle 716 on page 19

Variable Speed Reducer

Full constant torque conversion with variable horsepower through the entire speed range and speed variable down to 0 rpm are features of the Zero-Max mechanical power transmission and control. Described in illustrated bulletin MO856, it takes input speeds to 2000 rpm and is offered in various ratios. 12 pages. Revco Inc.

Circle 717 on page 19

Stainless Steels

Information provided in booklet on "Stainless Steel Types 308, 309 and 310" includes physical properties, heat treatment, strength at elevated temperatures, fatigue strength and resistance to oxidation. 8 pages. Allegheny Ludlum Steel Corp.

Circle 718 on page 19

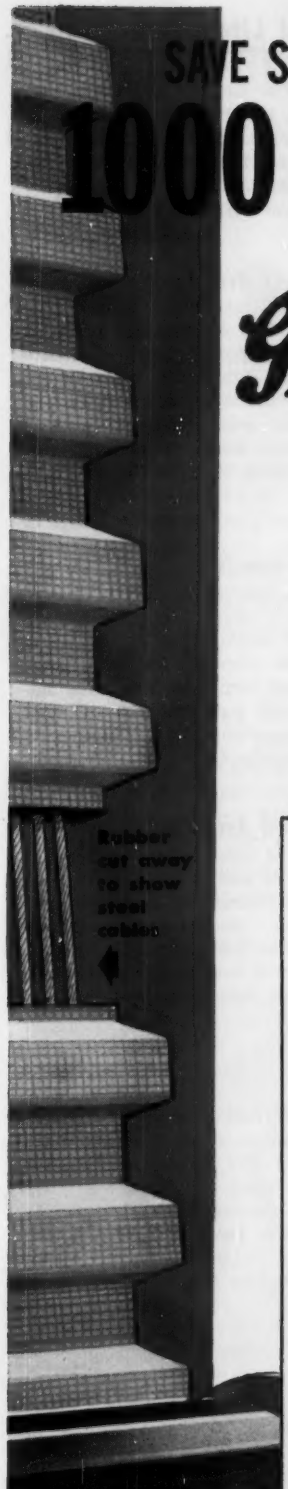
Air Control Valves

Dimensional data, parts list, description, price list and flow diagrams are included in data file on Starline series of air control valves. Series is group of five pilot heads which are interchangeable with seven valve bodies. 71 pages. Ross Operating Valve Co.

Circle 719 on page 19

Surface Profile Recorder

Flexible, accurate means for showing the true profile of practically any



SAVE SPACE AND COSTS...TRANSMIT UP TO *OR OVER*

1000 HP WITH THE NEW

Gilmer XX HEAVY DUTY

1¼" PITCH

"TIMING"® BELT DRIVE

TO HELP YOU COMPARE a Gilmer *XX Heavy Duty* "Timing" Belt drive with the four other common forms of power transmission of equal capacity, a power transmission engineer offers his recommendations based on published application and load ratings, for the following:

A 300-HP drive (at 1160 rpm.) including application factors
3.00: 1 speed reduction
Approximately 50" center distance

Here, complying with minimum pulley sizes and other practices commonly observed, are his recommendations (with approximate comparative cross sections of space occupied by each drive):

"TIMING" BELT DRIVE
Belt: XXH "Timing" Belt 10" wide by 160" P. L.
Motor Pulley: 9.549" P. D. (24-groove) 1¼"-pitch
Driven pulley: 28.648" P. D. (72-groove) 1¼"-pitch
Belt speed: 2900 feet per minute

V-BELT DRIVE
Belts: 10 Super Service "D"-Section V-Belts (DP-225)
Motor pulley: 18.0" P. D. x 10 D-groove, 14¾" wide
Driven pulley: 54.0" P. D. x 10-groove, 14¾" wide
Belt speed: 5380 feet per minute

GEAR DRIVE
Herringbone gear speed reducer with 3:1 ratio. (A typical reducer of required capacity weighs 1440 lb., measures 33" long, 26⅝" high and 19" wide.)

ROLLER CHAIN DRIVE
Chain: #80-8 (8 strands) 1"-pitch x 152 pitches
Motor sprocket: 7.979" P. D. (25 teeth)
Driven sprocket: 23.880" P. D. (75 teeth)
Chain speed: 2380 feet per minute
(Requires Type #3 lubrication with oil-tight case for sump pump)

FLAT BELT DRIVE
Belt: 21" wide x 8-ply x 18' 4" long
Motor pulley: 18" O. D. x 23" wide
Driven pulley: 54" O. D. x 23" wide
Belt speed: 5380 feet per minute

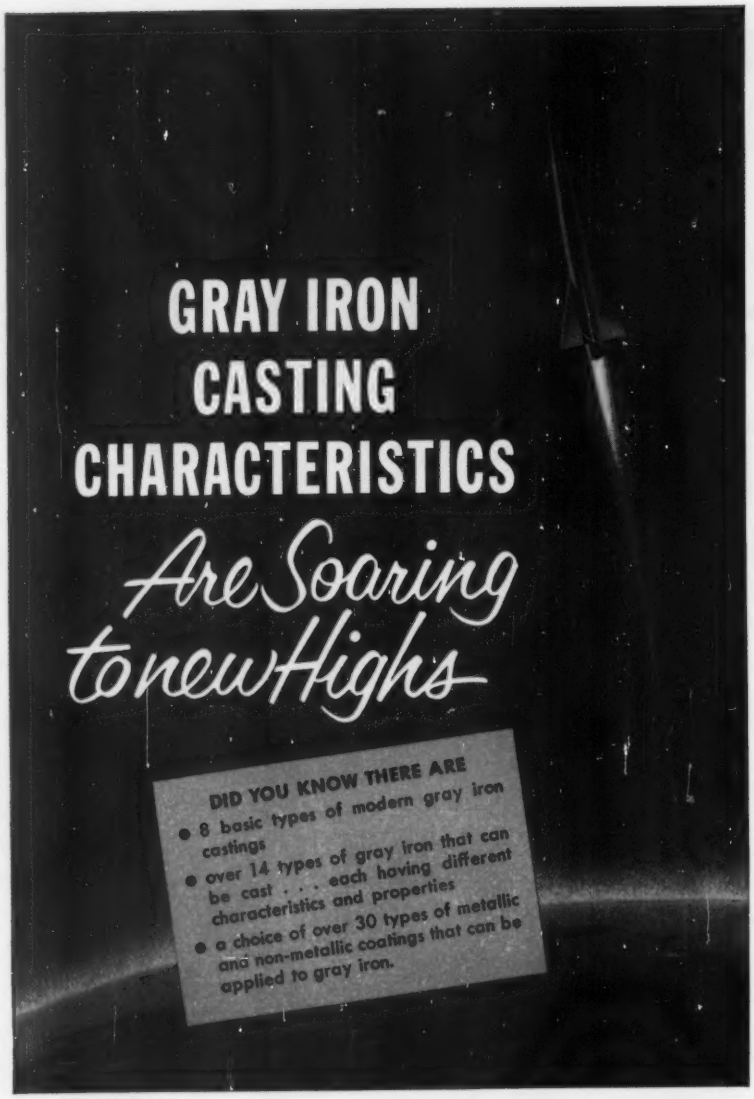
In cost and in weight the "Timing" Belt drive also has a big savings advantage. Ask your NYB&P-Gilmer Distributor for the figures.

NEW YORK BELTING & PACKING CO. • Founded 1846

NYB&P

NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products


GRAY IRON
CASTING
CHARACTERISTICS
Are Soaring
to new Highs
DID YOU KNOW THERE ARE
• 8 basic types of modern gray iron castings
• over 14 types of gray iron that can be cast . . . each having different characteristics and properties
• a choice of over 30 types of metallic and non-metallic coatings that can be applied to gray iron.

If you are on the lookout for new ways and means to improve your products *and save money, too,* investigate modern gray iron castings. Gray iron is not only the most economical of all basic components, but recent developments in new gray irons and casting techniques are elevating their utility to new highs. Today they possess a combination of essential engineering properties that cannot normally be duplicated in more expensive competitive materials. Acquaint yourself with the present and future possibilities of modern, controlled gray irons. Be sure that gray iron is making its full contribution to your products. Write for the GIFS "Summary of Specifications" today.

it's time to design with

GRAY IRON CASTINGS

GRAY IRON FOUNDERS' SOCIETY, INC.
National City-East 6th Bldg. • Cleveland 14, Ohio

Helpful Literature

machined or finished surface is provided by the Proficorder, described in illustrated bulletin LT-24. Reproductions of chart records are shown and applications are suggested. 4 pages. Micrometrical Mfg. Co.

Circle 720 on page 19

Welding Control Equipment

Bulletin GEA-5945A discusses all facets of G-E synchronous precision control equipment for resistance welding. It lists typical areas of application, describes components and accessories and discusses control's use in spot, seam, combination and bench welding. 8 pages. General Electric Co.

Circle 721 on page 19

Strip Terminals

Fingrip quick-disconnect strip terminals are offered in male, female and right angle types for wiring in stoves, oil burners, switches, fans, timers and harnesses. Test data bulletin covers pull-out, pull-off, heat tests, dimensions and installation. 8 pages. Burndy Corp., Omaton Div.

Circle 722 on page 19

Servoboard Assembly

Tables of common gear ratios and moments of inertia for gears are included in instruction sheet SBI-1 for Servoboard electro-mechanical assembly kits. Instructions for installing hangers, components in hangers, gears, gear alignment and gear selection are given. Servo Corp. of America.

Circle 723 on page 19

Thin Electrical Steels

Representative test results on three types and five thicknesses of thin electrical steel are presented in illustrated manual 4856. Covered are applications, availability, fabrication, properties, testing methods and conversion factors. Thirty-nine pages of design curves are inluded. 56 pages. Request directly from Armco Steel Corp., Middletown, O.

Gearing & Speed Reducers

Included in Gear Catalog No. 57 is information on gear materials and heat treatment, gear cutting capacities for all gear types, tooth forms, comparison for milled-form and generated spur gears, AGMA Class 1 horsepower ratings, AGMA horsepower formulas and lubrication specifications for line of gears and speed reducers. Request directly from Horsburgh & Scott Co., 5114 Hamilton Ave., Cleveland 14, O.

Circle 496 on page 19

(Advertisement)

How engineers eliminate costly manufacturing headache by

Adding One Specification to Prints

Cut Production Costs
While Improving Design

DESIGN and process engineers are now helping to get rid of one of the costliest headaches in almost every metalworking plant—the removal of burrs from machined parts. Such burr-removal often costs more than the original machining itself.

You too can do this for your parts—just by adding one dimensional specification that will cut costs and improve your product.

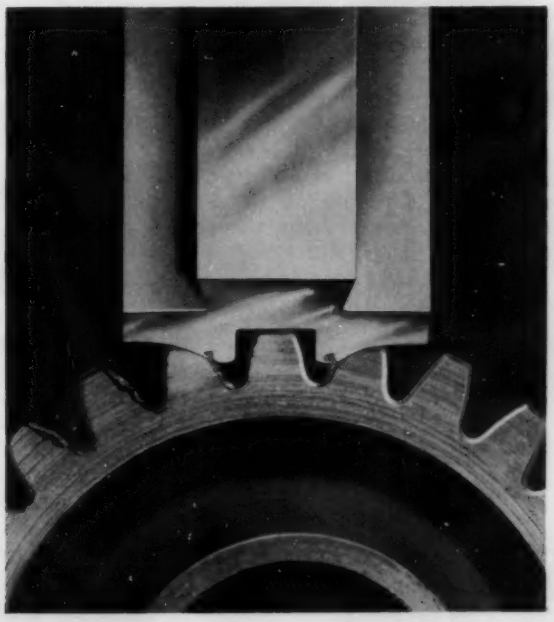
How?

Simply by specifying dimensional generated chamfers on parts prints. Specify them for those part edges on which burrs are normally left by machining. Such generated deburr-chamfers can now be accurately produced on MODERN Burr-Masters at amazingly low cost and high speeds. Symmetrical toothed elements, including internal and external gears, can be chamfer-deburred over the entire tooth contour—flank, tip, root and fillets—at an average speed of *five teeth per second!*

Note how the MODERN Burr-Master produces a generated chamfer that both positively removes the burrs and provides a functional chamfer of any reasonable width desired on the part.

There are many types of MODERN Burr-Masters to take care of different kinds of parts. They can even get into the most surprisingly inaccessible places to chamfer-deburr. Chances are we have just the Burr-Master to suit your needs.

Our engineering department will be happy to provide you with complete details. Therefore may we suggest you send them prints of some of your parts that now have to be deburred. If possible, include sample parts, with the burrs still on them.



MODERN®
Industrial Engineering Co.
14230 BIRWOOD AVE. DETROIT 38, MICHIGAN

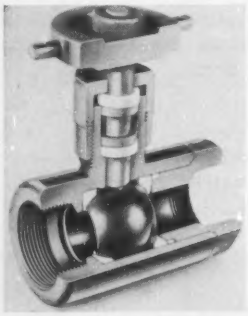
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

PVC Ball Valve

in ½ to 2 in. sizes

Polyvinyl chloride ball valve handles corrosive and other difficult fluids. It can be used in many plastic or metal piping systems for either vacuum or pressure service. Design includes full flow, quarter-



turn shut-off, with leaktight cycles and no maintenance. Valve seats and seals are easily replaceable. Rating is 150 psi at ambient temperatures and 50 psi at 130 F. The valve is complete with air operator for remote control and sequence operations. Sizes ½ to 2 in. in screwed end are available. **Jamesbury Corp.**, 62 Millbrook St., Worcester, Mass.

Circle 724 on page 19

Cast Teflon Film

new process provides extremely thin film

Cast Teflon film in thicknesses from 0.00025-in. up is made by depositing sub-micron-size particles of Teflon on a highly polished metal substrate. A series of operations results in heavier gages by fusing together separate layers; the 0.004-in. gage is formed of 12 layers. Films are free of voids, pinholes and physical surface disturbances, and possess high dielectric strength and life. Applications range from capacitor dielectric to wire insulation. **Dielectrix Corp.**, Allen Blvd. and Grand Ave., Farmingdale, N. Y.

Circle 725 on page 19

Aluminum Connectors

in shell sizes from ⅜ to 1⅜ in. ID

Miniature aluminum connectors weigh less and take up less space than standard AN connectors. Contacts are size 20, gold plated, and have machine-closed entry sockets. Quick-disconnect coupling between a modified double stub thread or three-point bayonet lock are available. Provision is made for grommet sealing, potting, cable sealing and conduit applications. Connec-

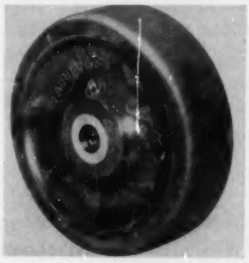
tors are available in a variety of shell styles and insert arrangements. Shell sizes range from ⅜ to 1⅜ in. ID and incorporate from 1 to 55 contacts. Manufactured by Scintilla Div. of Bendix Aviation Corp., connectors are available from **Avnet Eastern Sales**, 36 N. Moore St., New York 13, N. Y.

Circle 726 on page 19

Industrial Wheels

are of nylon-reinforced plastic

Lamilon nylon-reinforced all-plastic wheels for materials handling equipment have high impact strength and abrasion resistance. Water absorption factor is low, and they are unaffected by oils and greases and show high resist-

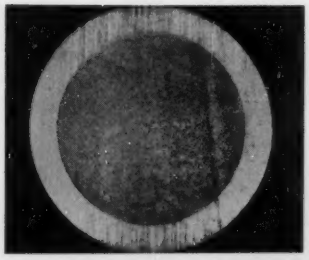


ance to most chemicals including acids, alkalies and solvents. They perform well in elevated temperatures. Available in sizes 3 through 12 in., wheels are sparkproof and have high load ratings. **Fairbanks Co.**, 393 Lafayette St., New York 3, N. Y.

Circle 727 on page 19

Communications Wire

has high tensile strength and good conductivity



Copperply communications wire is of high-strength steel with a heavy copper coating. It meets multiple requirements of high tensile strength (up to 250,000 psi), electrical conductivity, bright finish and resistance to fatigue and corrosion. Copper coating is joined to steel core in a permanent bond that permits twisting, stranding, weav-

Circle 498 on page 19→

IN ELECTRICWARE, TOO,

Sharonsteel Quality STANDS OUT

• There are so many advantages to stainless electricware it's no surprise that sales are skyrocketing. Homemakers like the natural beauty of stainless — the way it easily absorbs the punishment of everyday use and stays forever new with a minimum of care.

• Sharon's thorough knowledge of the utensil industry, the ability to produce specification steels of consistent uniformity, plus the finest finishes in the industry are reasons why so many of the nation's leading electricware manufacturers specify **Sharon Quality Stainless Steels.**

172

SHARONSTEEL *For 56 Years a Quality Name in Steel*

SHARON STEEL CORPORATION, SHARON, PENNA.

CHICAGO, CINCINNATI, CLEVELAND, DAYTON, DETROIT, GRAND RAPIDS, INDIANAPOLIS, LOS ANGELES, MILWAUKEE, NEW YORK, PHILADELPHIA, ROCHESTER, SAN FRANCISCO, SHARON, MONTREAL, TORONTO

Promet Engineered Bronze
BEARINGS
BUSHINGS
WEARING PARTS
GUARANTEE
SUPERIOR
SERVICE
Or Your Money Back!

Special formulas developed for specific or unusual conditions. Will not cut or stick to the shaft under ordinary operating conditions. Carry on during temporary lubrication failures. Absolutely will not powder in severest service.

Highest quality machining to precisely controlled tolerances. Difficult oil grooving . . . smooth grooves, even around acute bends . . . no sharp edges or burrs . . . remarkably better lubrication. Also available rough cast.

Send prints and condition of operation for recommendations, quotations, literature and service data sheets.

The
American Crucible
PRODUCTS CO.
"Bearing Specialists Since 1919"
1321 OBERLIN AVENUE, LORAIN, OHIO

Please send free literature and service data sheets on Promet Bronze.

NAME_____
COMPANY_____
STREET_____
CITY & STATE_____

Circle 499 on page 19

New Parts

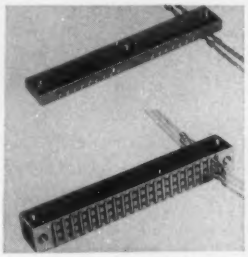
ing, braiding, bending or flattening wire without rupturing the bond. Wire is available in two grades, with 30 and 40 per cent conductivity and in both high and extra-high strength classes. Diameters from 0.0640 to 0.2893-in. are produced. **National Standard Co.,** 1939 Ward Rd., Niles, Mich.

Circle 728 on page 19

Terminal Blocks

provide taper-pin solderless connections

Improved terminal-block design features precision-reamed tapered receptacles to allow solderless connections. Positive locking is given between taper pin and molded-in machined receptacle. Series 145-58 terminal blocks have single row



of 20 contacts, 10 dual contacts, or 10 single contacts in any pair or combination of shorted contacts. Series 145-48 blocks have 20 rows of triple-stacked contacts in any desired shorting combination. Receptacles are gold-plated brass over silver for low contact resistance. **DeJur-Amsco Corp.,** Electronics Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 729 on page 19

Ultrasonic Generators

drive low-impedance ultrasonic transducers

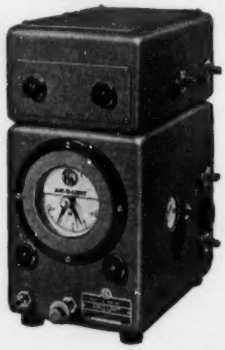
Glennite U-405 ultrasonic generators are designed to drive a variety of low-impedance ultrasonic transducers. Useful for electromechanical techniques, such as cleaning, chemical processing, soldering and drilling, the generators have an untuned output system and 500-w RF power output, plus a range of frequency levels. They are blower-cooled and operate at a nominal

BUILD A GAGE INSTALLATION TO SUIT YOUR NEEDS . . .

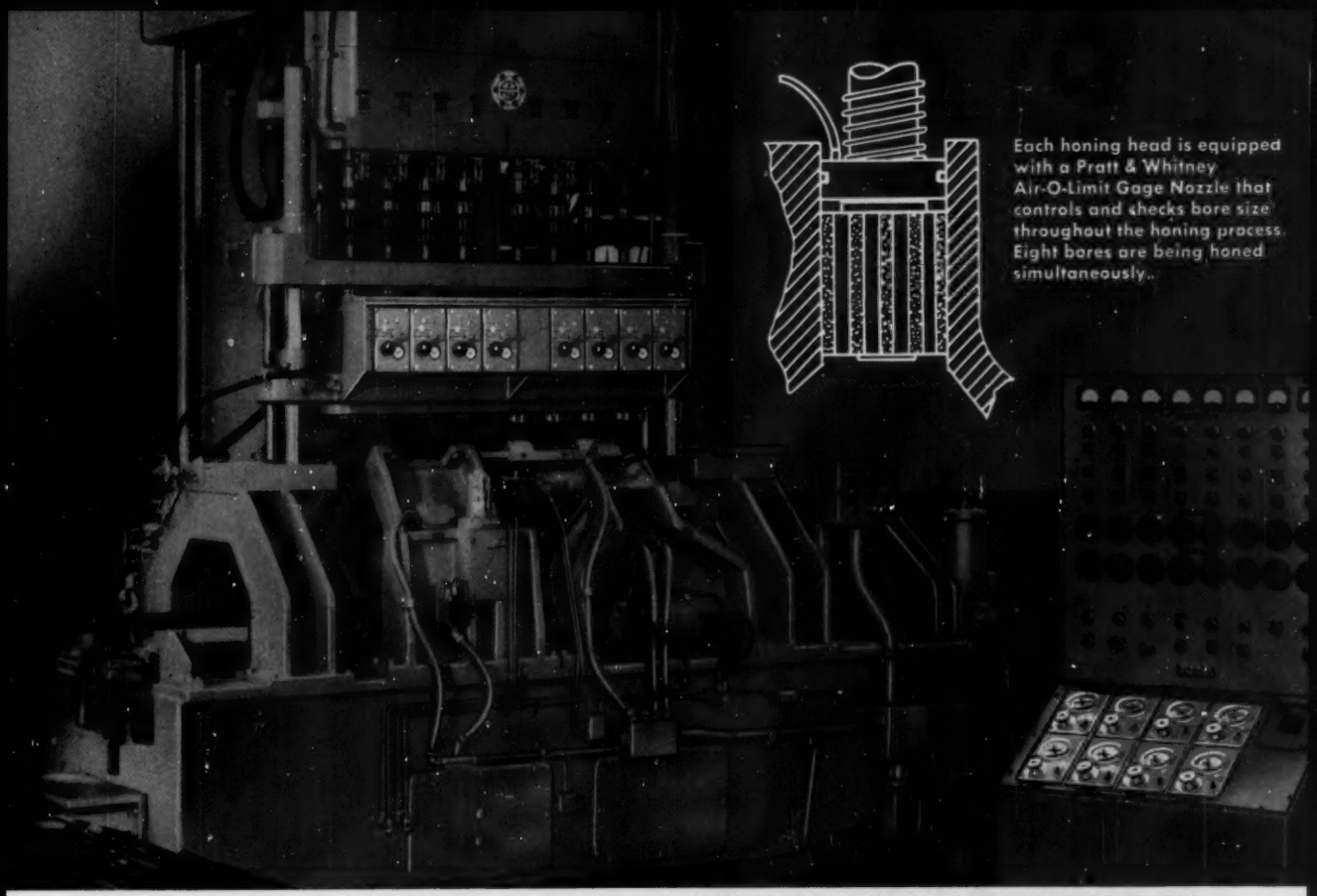
with these packaged, on-the-shelf P&W Air-O-Limit Light Signal Units. Can be used to signal operator or to provide feed-back impulse for fully automatic process control.

BASIC 2-LIMIT UNIT . . . indicates high and low tolerances. Suitable for sorting and other "yes-or-no" control applications.

3-LIMIT UNIT . . . especially suited for grinding and similar operations. Indicates or automatically controls such conditions as: "Fast Feed," "Slow Feed," and "Spark-Out."



4-LIMIT UNIT . . . similar to 3-Limit Unit, but provides greater control scope. Indicates or controls such conditions as: "Approach High Limit," "High Limit," "Approach Low Limit" and "Low Limit."



Each honing head is equipped with a Pratt & Whitney Air-O-Limit Gage Nozzle that controls and checks bore size throughout the honing process. Eight bores are being honed simultaneously.

PHOTO COURTESY OF MICROMATIC HONE CORPORATION, DETROIT, MICH.

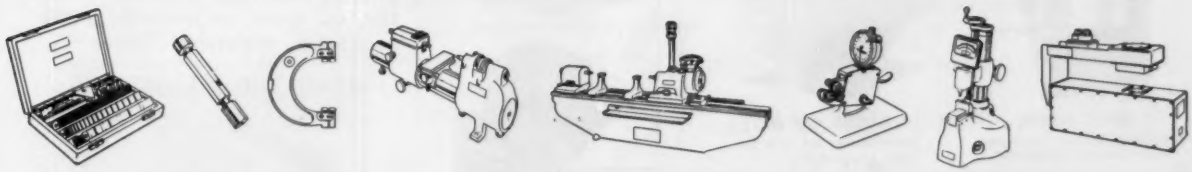
Design Higher Production into Your Machines THE EASY WAY

• • • • WITH PRATT & WHITNEY "PACKAGED" AUTOMATION GAGE UNITS

Pratt & Whitney "Automation Gaging" is fully automatic control of product size by means of "feedback" impulse from automatic gages to the machine. Applied to your designs, Automation Gaging can help you provide performance standards that will increase production rates, reduce scrap losses and take full advantage of the high precision built into your machines. In addition, Pratt & Whitney standard, on-the-shelf Packaged Gage Units provide an installation *custom-tailored* to your design requirements *without* the expense and delays involved in engineering and constructing special controls.

In this example – a Micromatic Hydrohoner – automotive cylinder blocks are gaged *during* the Microhoning process. When final size is reached, the machine is automatically shut off and the Microhoning tools are retracted. A change to a different bore size can be made without stopping the machine, by a simple adjustment on a calibrated gage control dial. Visual indication is given of the accuracy of the new adjustment. Cylinder blocks are produced at a rate of 120 per hour. Reject and scrap losses are virtually eliminated.

Call in a P&W Field Engineer to analyze your requirements and recommend the right P&W Automation Gaging installation to meet your needs exactly. Pratt & Whitney Company, Incorporated, 33 Charter Oak Boulevard, West Hartford, Connecticut.



GAGE BLOCKS . . . CONVENTIONAL GAGES . . . SUPERMICROMETERS . . . STANDARD MEASURING MACHINES . . . COMPARATORS . . . AUTOMATION AND CONTINUOUS GAGES

PRATT & WHITNEY

FIRST CHOICE FOR ACCURACY

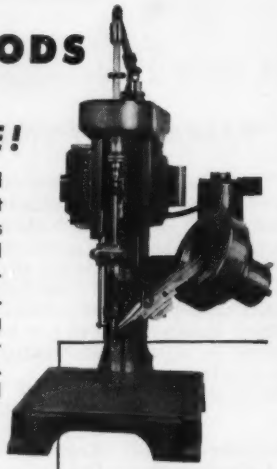
MACHINE TOOLS • GAGES • CUTTING TOOLS

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Double pressure: stiff competition and rising costs can cause profits to falter . . . .

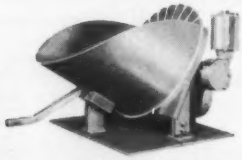
DPS POWER ASSEMBLING METHODS will help sustain THAT PROFITS LINE!

• Though profits may continue to move upward under present conditions, profit increases may not match sales advances. Here is where DPS methods with their time-saving, stepped-up output and lower costs can meet the situation effectively. Results in progressive plants everywhere prove it. Plan now to put more profit into your feeding and assembling operations. DPS POWER SCREWDRIVERS and SELECTIVE PARTS FEEDERS will do it. Write us, give details. We'll send catalog and recommendations.

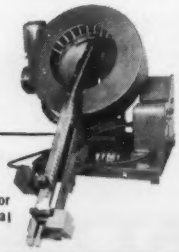


SCREWDRIVING MACHINES
Bench and Pedestal Types
5 Models

BOWL FEEDER
Electrical vibratory type to feed parts that cannot be tumbled.



BARREL FEEDER
with stationary ring cover for heavy-duty production.



BARREL FEEDER
Popular motorized type, for parts requiring critical selection.

DETROIT POWER SCREWDRIVER CO.

2801-A W. FORT ST. DETROIT 16, MICHIGAN

New Parts

fixed frequency of 40 kc or at any frequency between 20 kc and 2 mc, depending on model. **Gulton Industries Inc.,** 212 Durham Ave., Metuchen, N. J.

Circle 730 on page 19

Flexible Magnetic Plastic

for miniaturization of magnetic designs

Flexible ferromagnetic plastic, designated Ferrotron, possesses good dielectric strength, constant magnetic permeability over a wide range of frequencies to 3000 mc, and excellent moisture and temperature resistance to 200 C. Avail-

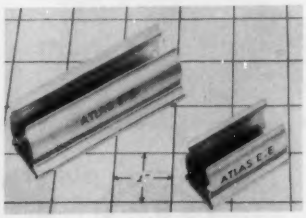
able in rod and tape form, material is offered in sample kits and production quantities to electronic designers for investigation and fabrication of new concepts in circuit development, including miniaturization of components. Rod diameters are ⅛, 3/32 and ¼-in. Tape is ½-in. wide in thicknesses of 0.004, 0.008, 0.016 and 0.032-in. **Polymer Corp. of Pennsylvania,** 2140 Fairmont Ave., Reading, Pa.

Circle 731 on page 19

Component Holders

in 300 new variations offer protection to 90 *g*

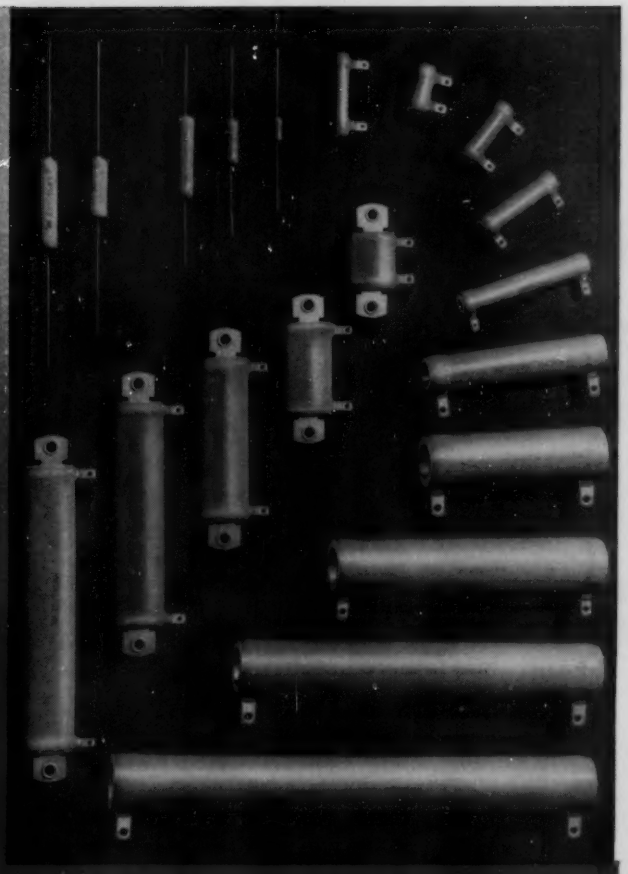
Clip-type component holders, for meeting conditions of severe vibration and shock, are available in 300 additional variations. These in-



clude: lightweight slotted holders for glass, paper and plastic envelopes and cases such as submini-

Circle 500 on page 19

Now! Vitrohm MIL-R-26C Resistors in all styles!



Famous Ward Leonard Vitrohm® vitreous-enameled resistors are now available in every style to meet all requirements of Military Specification MIL-R-26C including the severe bogeys on moisture resistance, thermal shock, insulation resistance and many other properties.

What's more, this line offers you *all* characteristics—G, V, and the exacting Y—and *all* specification sizes and resistance values—even the highest values using the finest wire (0.00175" dia.) permitted by the spec.

Tab-terminal, axial-lead and stack-mounting types are available in styles and characteristics shown in table.

For complete data on these MIL-R-26C resistors, write us for Bulletin 12. (And incidentally, for Vitrohm resistors to *highest commercial and industrial standards*, get W/L Catalog 15.) Ward Leonard Electric Co., 58 South Street, Mount Vernon, N.Y. In Canada: Ward Leonard of Canada Ltd., Toronto.

ENGINEERING DATA

TYPE	STYLE	AVAILABLE IN CHARACTERISTICS	RESISTANCE RANGE
Stack Mtg.—Tab	RW20 thru 24	G	All values in Spec.
Tab terminal	RW29 thru 47	V, Y* and G	All values in Spec.
Axial lead	RW55 thru 59	V and G	All values in Spec.†

*Characteristic Y applies to styles RW30, 33, 37 and 47 only. Characteristic Y is similar to V but requires high insulation resistance at end of moisture-resistance tests.

†Maximum values for single-layer-wound resistors with 0.00175" diameter wire.

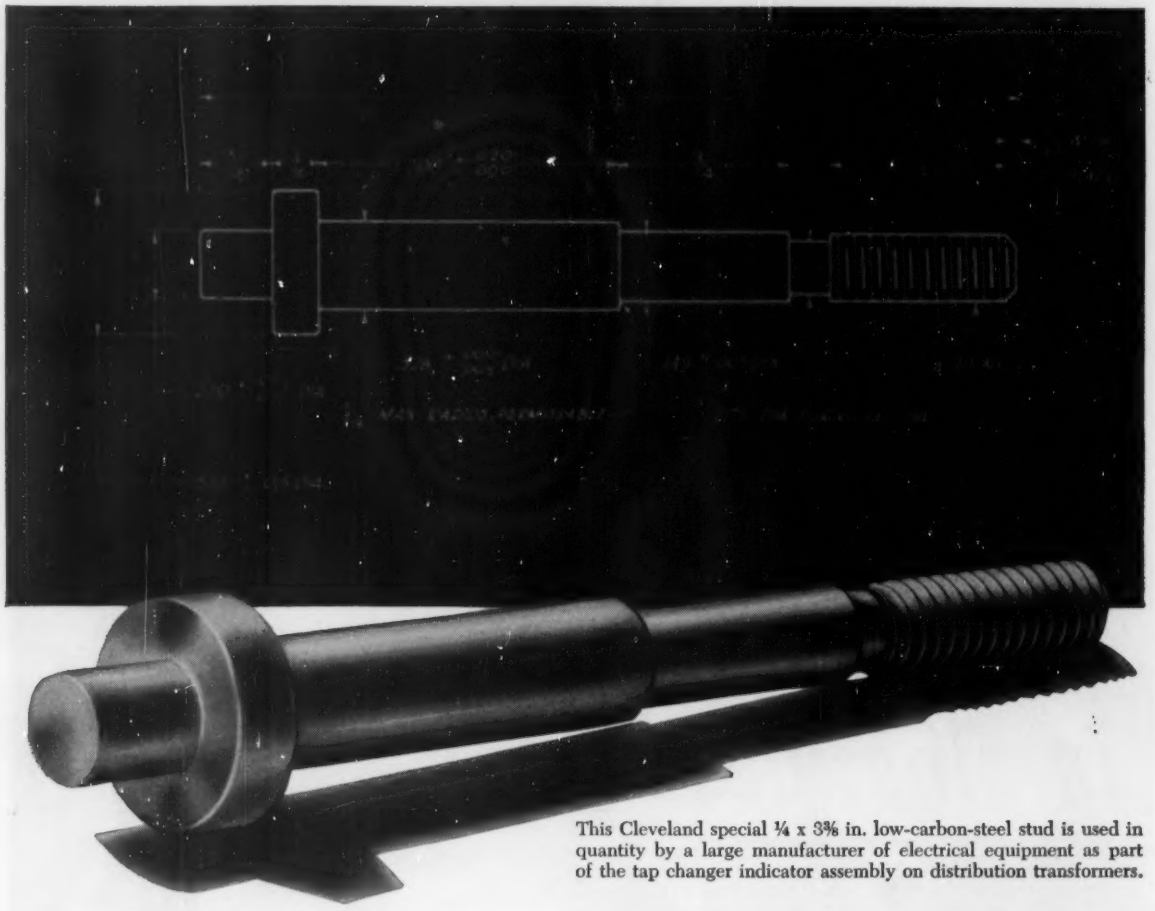
LIVE BETTER...*Electrically*

7.7

WARD LEONARD ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

Result-Engineered Controls Since 1892

CLEVELAND SPECIAL HEADED AND THREADED PRODUCTS



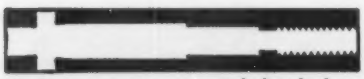
This Cleveland special ¼ x 3⅜ in. low-carbon-steel stud is used in quantity by a large manufacturer of electrical equipment as part of the tap changer indicator assembly on distribution transformers.

Cost of special collar stud is cut 20% by Cleveland's cold forming techniques

The famous Kaufman Double Extrusion Process which turns out millions of Cleveland precision cap screws yearly is highly adaptable to low-cost production of your fastener-type specials.

The tap changer stud pictured above is typical. Used by a well-known electrical equipment manufacturer, it was previously cut from bar stock. The special head, double shoulders, and groove above the threads meant numerous machining operations and considerable scrap.

♦ ♦ ♦



Black area represents metal that had to be cut away when stud was produced by machining. In the Cleveland cold forming process almost all the metal in the working slug is present in the finished part. The customer saves the difference.

Cleveland now cold forms this special stud at 20% less cost to the customer, while holding the specified .005 in. tolerance. And the part is stronger. In the head, threads and fillets, grain flow is symmetrical and unbroken. In addition, the forging action of the Kaufman process toughens surface metal while leaving the core ductile. Both fatigue resistance and tensile strength are thus increased.

We are regularly cold forming close-tolerance specials—many with unusual or extreme upsets—in large quantities. So whether your part is simple or complex, it will pay you to check with Cleveland, particularly at the design stage. There is an excellent chance that through cold forming we can cut the cost and improve the physical properties of the part you have in mind.

Write for a copy of our folder "Specials by Specialists"

THE CLEVELAND CAP SCREW COMPANY
4444-6 Lee Road, Cleveland 28, Ohio

Circle 502 on page 19

ture tubes and capacitors; silver-plated beryllium-copper holders for applications requiring nonmagnetic material; and heat-treatable silver alloy holders for applications requiring maximum heat dissipation. All have been tested to 90 *g* at 2000 cycles without resonant frequencies. Holders are available in diameters from ⅛ to 1½ in. with lengths from 3/16 to 4 in. **Atlas E-E Corp.**, 47 Prospect St., Woburn, Mass.

Circle 732 on page 19

Power Pickup

operates low-voltage relays without amplifier

Power pickup serves as a self-generating power source for operating directly over and under-speed controls or warning devices and provides sufficient power to operate low-voltage relays without amplification. At actuating speeds of 250 in. per sec or more, unit pro-

vides sufficient power to operate relays having 100 mu w sensitivity. When used with two germanium diodes in a voltage-doubler circuit, unit will operate a conventional 2500-ohm vacuum tube plate circuit relay. Temperature limit is 200 F. Size is 2⅜ in. overall length by ¾-in. diam. **Electro Products Laboratories**, 4501 Ravenswood Ave., Chicago 40, Ill.

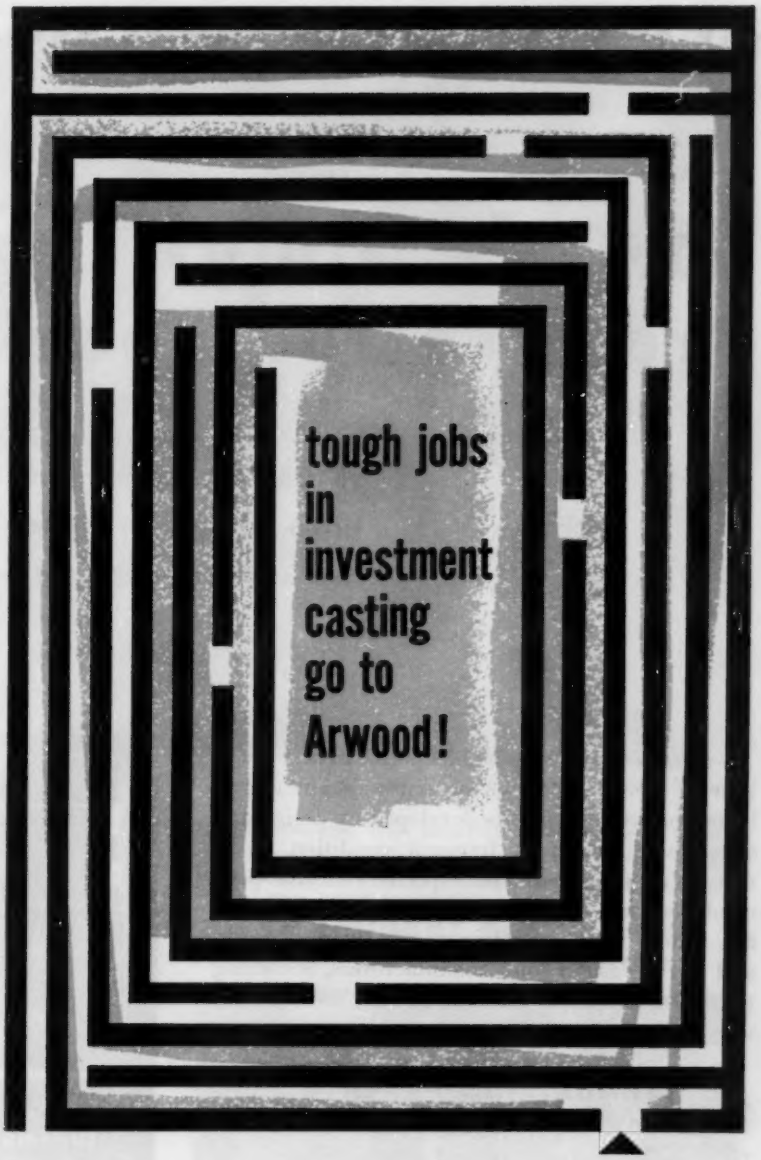
Circle 733 on page 19

Passive Cathode Alloy

for electronic tubes in high-shock applications

Cathaloy P-51 passive cathode alloy contains 4 per cent tungsten to increase its strength. Hot yield strength is approximately 5000 psi at 800 C. Material is designed for electronic tubes which require low rate of barium evolution, minimum sublimation and freedom from in-

(*Continued on Page* 196)



"Tough" Investment Casting jobs are the rule at ARWOOD, not the exception.

Intricate shapes, unusual contours, fine detail, metals and alloys difficult or impossible to machine, rigid quality control specifications, unyielding performance requirements . . . Add them all together and they total a "tough" job.

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315 West 44th Street, New York 36, N. Y.

Plants: Brooklyn, N. Y. - Groton, Conn. - Tilton, N. H. - Los Angeles, Calif.
"PIONEERS IN INVESTMENT CASTING"

Circle 503 on page 19

ONE OF A SERIES OF INFORMATIVE MESSAGES FROM HYATT . . .

Hyatt's Simplified Fitting Practice for Bearing Races

HYATT pioneered the use of carburizing type alloys in order to obtain the advantages of heavier race fits

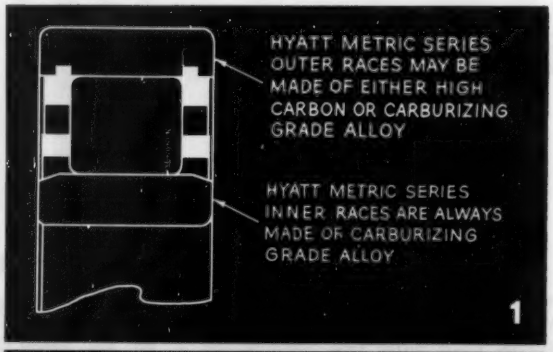
To obtain the best possible performance, roller bearing races must be assembled on shafts and in housings with certain fits developed by design and experience. The most frequent condition to be met is a rotating shaft where specific load and speed conditions must be satisfied with appropriate race fits. These vary according to the manufacturer, and in the case of some manufacturers, according to the application. Naturally, the fits will also vary according to bearing type and size.

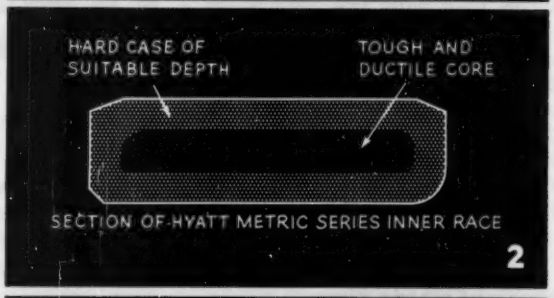
1. CARBURIZING PERMITS HEAVIER INTERFERENCE FITS

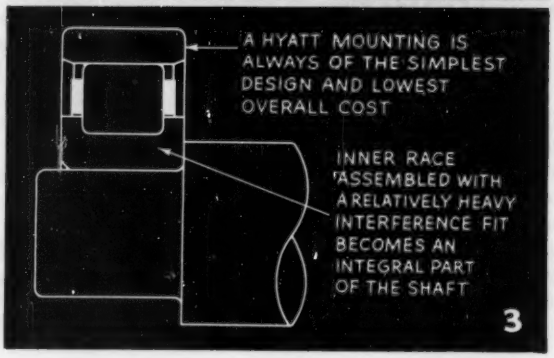
Taking the standard metric series of cylindrical roller bearings for an example, the bearing user has the choice of two fitting practices. One involves the use of inner races made of through-hardening steel, which dictates fairly light interference fits to avoid splitting. The other utilizes races made of low carbon steel *carburized* and hardened to develop a suitable surface hardness and a tough ductile core. The latter permits much heavier interference fits and has the additional advantage of eliminating all auxiliary holding devices, because the race becomes practically an integral part of the shaft. (Figs. 1, 2.)

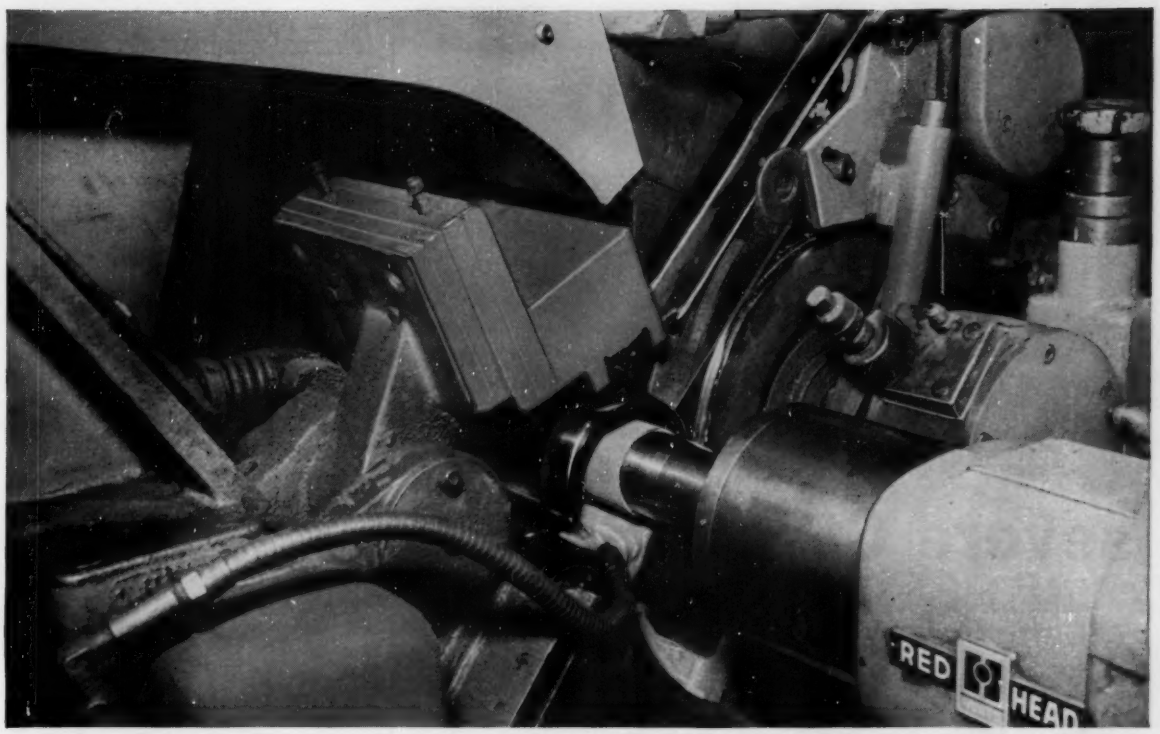
2. HEAVIER FITS SIMPLIFY MOUNTING, REDUCE COSTS

Hyatt originated the carburized race and the system of relatively heavy inner race fits to simplify bearing mounting and eliminate the need for retaining devices. Practically all HYATT inner races are made from nickel alloys of the carburizing type. They permit mountings of the simplest type and lowest over-all cost. Furthermore, the shoulders of HYATT carburized races will withstand considerably greater impact loads than will ordinary races. (Figures 3 and 4.)


HYATT METRIC SERIES OUTER RACES MAY BE MADE OF EITHER HIGH CARBON OR CARBURIZING GRADE ALLOY
HYATT METRIC SERIES INNER RACES ARE ALWAYS MADE OF CARBURIZING GRADE ALLOY
1




A HYATT MOUNTING IS ALWAYS OF THE SIMPLEST DESIGN AND LOWEST OVERALL COST
INNER RACE ASSEMBLED WITH A RELATIVELY HEAVY INTERFERENCE FIT BECOMES AN INTEGRAL PART OF THE SHAFT
3

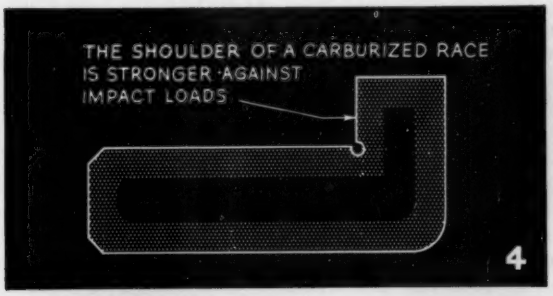


Hyatt inner race being centerless I. D. (inside diameter) ground to close tolerances.

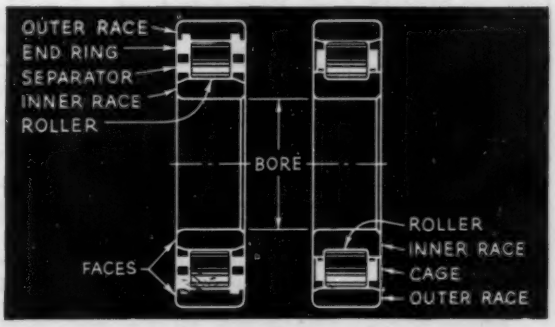
There are two fitting specifications which apply to HYATT inner races, depending on whether the inner race rotates or is stationary in operation. Remember, with both inner and outer race, the rotating member is assembled with heavier fit.

3. HYATT INNER RACES CAN BE EASILY SHRUNK ON SHAFTS

HYATT inner races may be mounted on shafts by pressing or shrinking. Where shrinking practice is employed, first heat the race in oil held at a temperature not over 300°F, or in an electric oven under a similarly controlled temperature, until it expands sufficiently to be slipped into position. The required interference fit will develop as the race cools in place. For special conditions of fit involving hollow shafts of varying sections or multiple housings of dissimilar metals, consult your HYATT Sales Engineer from our nearest sales office.



COMPONENT PARTS OF A HYATT ROLLER BEARING



YOU WILL FIND MORE DETAILS in HYATT Catalog No. 150. If you do not have a copy, write Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey. Sales offices at Harrison, Pittsburgh, Chicago, Detroit and Oakland, California.

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

GM GENERAL MOTORS

IS YOUR PROBLEM:

WEAR plus severe CORROSION?

Then you'll be interested in investigating Kennametal* Grade K501

Kennametal Grade K501, a platinum bonded tungsten carbide, was developed especially to meet conditions where severe abrasive conditions as well as corrosive agents are encountered. While K501 equals the corrosive resistance of the noble metals, it is lower in cost, and has a much higher resistance to wear.

Here are results of laboratory corrosion tests, showing comparisons with other metals which were developed specially for corrosion resistance:

	STRENGTH % by WT.				TEMPERATURE				LOSS† mg/dm/d			
SOLUTION	Kennametal K501	Monel Metal	Hastaloy B	Kennametal KM	Kennametal K501	Monel Metal	Hastaloy B	Kennametal KM	Kennametal K501	Monel Metal	Hastaloy B	Kennametal KM
Nitric Acid (HNO_3)	5	Above 1	—	5	Boiling	Above 80°F	—	Room	0	Not	—	587
Sulfuric Acid (H_2SO_4)	5	Above 20	10	5	Boiling	Boiling	Boiling	Room	0	Recom-	85	161
Hydrochloric Acid (HCl)	1.25	All	10	5	Boiling	Above 120°F	Boiling	Room	74	mended	77	245

†Tests of one week duration Note: The above tests are indicative of what may be expected in service, but it is recommended that specific tests under specific conditions be made.

In addition to its unusual abrasion and corrosion resistance properties, Kennametal K501 has a Hardness of 91.8 Rockwell A, Transverse Rupture Strength of 125,000 psi, and a Specific Gravity of 15.50. These unique properties suggest its use in valve parts, nozzles, seal rings, balls, non-lubricated guides and bushings, and other parts exposed to strong mineral acids, fuming nitric acid, and similar highly corrosive agents.

Made by Kennametal's exclusive methods of powder metallurgy, K501 can be produced in many complex shapes to close tolerances to meet the requirements for specific parts. It can be fastened by brazing.

Why not investigate Kennametal K501? It may be the answer to your problem. Write KENNAMETAL INC., Latrobe, Pennsylvania.

*Kennametal is the trademark of a series of tungsten and titanium carbides which have exceptionally high resistance to the destructive forces of abrasion, corrosion, erosion, deflection, deformation, high temperature oxidation and impact.

B-5983

See our catalog in Section 1b/Ke, Product Design File, Sweet's Catalog

INDUSTRY AND KENNAMETAL ...Partners in Progress

Circle 505 on page 19

New Parts

(Continued from Page 193)

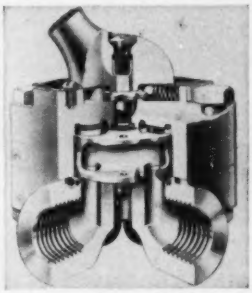
terface impedance. It is especially useful in ruggedized tubes. Alloy is available in seamless, welded and cold drawn, and Lockseam forms to exact dimensional specifications. **Superior Tube Co.**, Germantown Pike, Norristown, Pa.

Circle 734 on page 19

Selector Valve

leakproof unit for liquids to 1000 psi

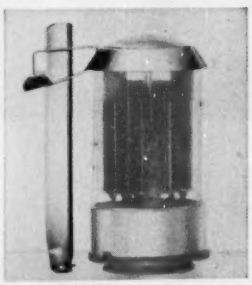
Seal-tite selector valve, in indexed positions, gives no-leak service for air, gases, hydraulic oil, nonaromatic fuel, petroleum, or water. Working pressures are 0 to 500 psi for air and gases and 0 to 1000 psi for liquids. Operating temperature range is −65 to 160 F. Dynamically loaded sealing rings on opposing sides of valving-disk seal tighter as pressure increases. Reversal of flow at any pressure, or lack of pressure, will not unseat seals. Port sizes are ⅛-in. to 1 in. **Republic Mfg. Co.**, 15655 Brookpark Rd., Cleveland 11, O.



Circle 735 on page 19

Tube and Component Retainer

guards tube against severe shock or vibration



Stainless-steel top-holding tube and component retainer conforms with

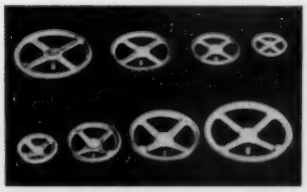
military approved method of tube retention. Consisting of two parts, a post and a cap, unit is available in single and double-post styles to hold all tubes and cylindrical components from 7/8 to 2 15/16 in. in diam. Post heights range from 7/8 to 5½ in. (increments of ⅛-in.). Device holds tubes and components securely under severe shock and vibration, yet can be removed readily. **Birtcher Corp.**, Industrial Div., 4371 Valley Blvd., Los Angeles 32, Calif.

Circle 736 on page 19

Hand Wheels

are cast in lightweight aluminum

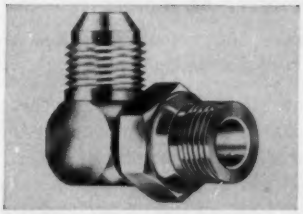
Straight and angular hand wheels are lightweight aluminum castings, plain or finished, with or without lug for revolving handle. Straight wheels are available with 6, 8, 10 and 12-in. diameters; angular wheels in 7 diameters from 4 to 14 in. Four and five-inch diameter wheels are solid-disk type without spokes. Wheels from 6 to 10 in. in diameter are standard four-spoke models, as shown. The 14-in. wheel has five spokes. **Jergens Tool Specialty Co.**, 712 E. 163rd St., Cleveland 10, O.



Circle 737 on page 19

Straight-Thread Fitting

provides positive seal of hydraulic fluids



Elbow-shaped CN captive-nut straight-thread fitting provides positive seal of all hydraulic fluids without use of an O-ring. It is

Acme

DOUBLE PITCH CHAINS become more popular with every application

Double pitch chains are becoming increasingly popular for applications where a precision roller chain is required and where cost is an important factor.

Acme's double pitch precision chain is available in standard steel and in a stainless steel line up to and including 1½" pitch for conveyors in the packaging, aircraft and many other industries. Stainless steel provides the greatest resistance to corrosion, which is an important factor in these industries.

If you use continuous process machinery in textile, agricultural, building, material handling, food processing, bottling or other fields, you should insist on Acme precision built double pitch roller chain. Acme stands up to your performance expectations.

Available from stock at your Acme distributor.

FREE CHAIN CATALOG

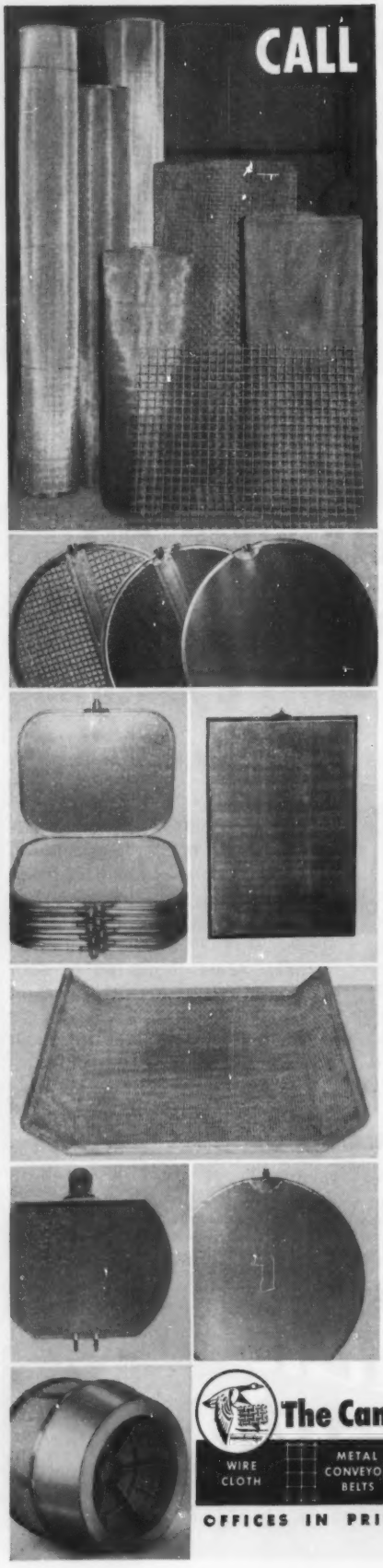
Write Dept. 6-J for your 80-page copy of Acme's latest catalog. Packed with valuable chain data. An indispensable chain reference.

Call ACME for Service

Acme Chain Corporation

HOLYOKE MASSACHUSETTS

Circle 506 on page 19



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INDUSTRIAL
WIRE CLOTH
in BULK
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COMPLETE LINE

Nine weaves ranging from the finest to the coarsest, in any metal or alloy.

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OFFICES IN PRINCIPAL INDUSTRIAL CITIES

New Parts

highly resistant to vibration and intense heat, eliminates stress, and can be assembled and reassembled without damage to port or fitting. Fitting allows minimum 405 deg for positioning in port. Burnished seats provide leakproof joints, and induction-toughened tube outlets prevent collapse of flare seat and stripping of threads. Radius corners provide free flow passages. **L & L Manufacturing Co.,** 8088 E. Nine Mile Rd., Van Dyke, Mich.

Circle 738 on page 19

Load Wheel

has high load-carrying capacity

Disowheel, with a tire composed of Disogrin, offers long tire wear, low power consumption and increased load capacity for materials handling equipment. Load-carrying capacity is rated to 2000 lb for a 3×4-in. wheel. Wheel withstands heavy stationary loads for extended periods without developing appreciable flats. It has low rolling resistance and high abrasion resistance. Other features include resilience value of approximately 25 to 60 per cent, excellent oil, ozone and sunlight resistance, and excellent floor protective qualities. **Greer Industries Inc.,** N. Y. International Airport, Jamaica 30, N. Y.

Circle 739 on page 19

Miniature AC Motors

have 102 planetary ratios from 4:1 to 3,000,000:1

Type FC standard motors, for 115 or 200 v ac, 60 or 400 cycles, are wound for single-phase (with capacitor) or two-phase operation, two, four or six pole, and three phase, two and four pole. Motors can be furnished with integral planetary gear reducers, offering 102 ratios between 4:1 and 3,000,-

Circle 507 on page 19

Circle 508 on page 19→

ROTO-FLO formed parts are produced faster, at lower cost, are stronger than machined parts of the same dimensions, have higher fatigue resistance.

LET US PROVE IT ON *Your* PARTS

You can now have your own experimental toothed parts (including involute splines, oil grooves, etc.) ROTO-FLO formed

without buying a machine

You can prove to yourself and your company that ROTO-FLO forming will improve performance and life while lowering production costs of

your own actual parts

All you pay for is an experimental pair of racks, and special tooling if needed.

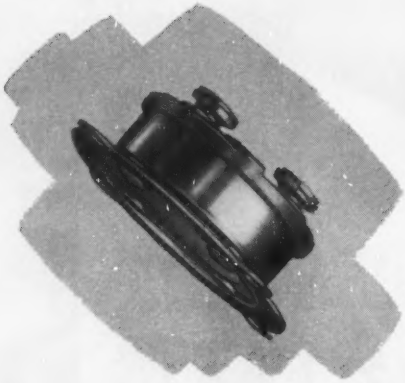
We will roll-form an experimental run of your test parts for you

Our field engineer in your area will be happy to work with you. May we ask him to supply you with complete information?

Please let us know

MICHIGAN TOOL CO.

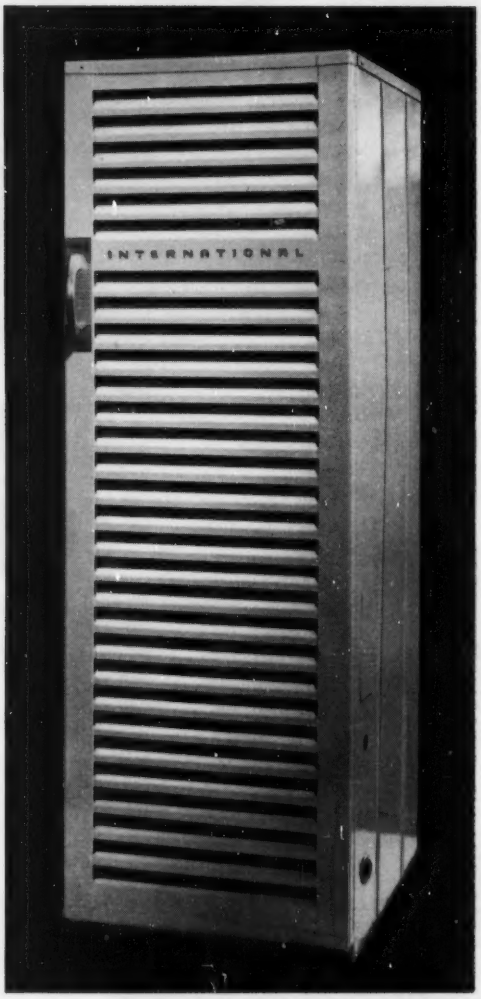
7171 E. McNICHOLS RD., DETROIT 12, MICH., U.S.A.
IN CANADA: COLONIAL TOOL CO. LTD.



KLIXON

SNAP-ACTING CONTROLS

are designed into International's Mobile Home Furnaces for dependable performance



In developing its automatic central furnace for mobile homes, the International Oil Burner Company, like other leading heating equipment manufacturers, chose KLIXON Controls on the basis of performance.

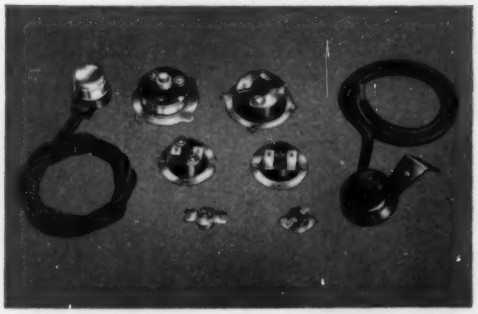
International's TAC 1000, which is compactly designed to fit into mobile home cabinet space and deliver 43,000 BTU/hr., uses KLIXON Controls in hi-limit, low-limit and fan control applications.

The inherent snap-action operation and rugged construction of KLIXON Controls make them especially suited for uses such as this.

Here's what Jordan Heiman, Superintendent of Research for International, has to say about these KLIXON Controls:

"In designing domestic warm air heating equipment, we find our limit applications generally require controls which operate consistently at high temperatures with electrical loads varying from millivolt circuits to high voltage. KLIXON Controls have most often met our specifications."

Designers and manufacturers who seek dependable, trouble-free performance in temperature controls are turning more and more to KLIXON. A wide variety of open and hermetically sealed types of KLIXON Controls are available with fixed temperature settings engineered to meet your requirements. Write today for Catalog THSN.



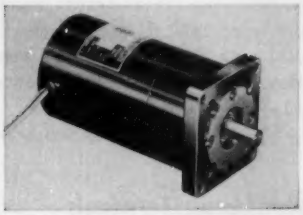
KLIXON®

METALS & CONTROLS CORPORATION

SPENCER THERMOSTAT DIVISION

3203 FOREST STREET, ATTLEBORO, MASS.

000:1. Up to 306 standard output speeds are available by varying the speed of basic motor. Gear-



reduced motors are supplied with induction or hysteresis rotors. The former produces up to 3.5 oz-in. of torque; the latter, operating at synchronous speed, produces up to 1.2 oz-in. torque. Motors are 1.675 in. in diameter and up to 4.5 in. long. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton, O.

Circle 740 on page 19

Check Valve

aluminum unit for 3000-psi service

MS-approved, ½-in. aluminum alloy check valve for 3000-psi service in aircraft applications, has a 55 per cent weight saving over

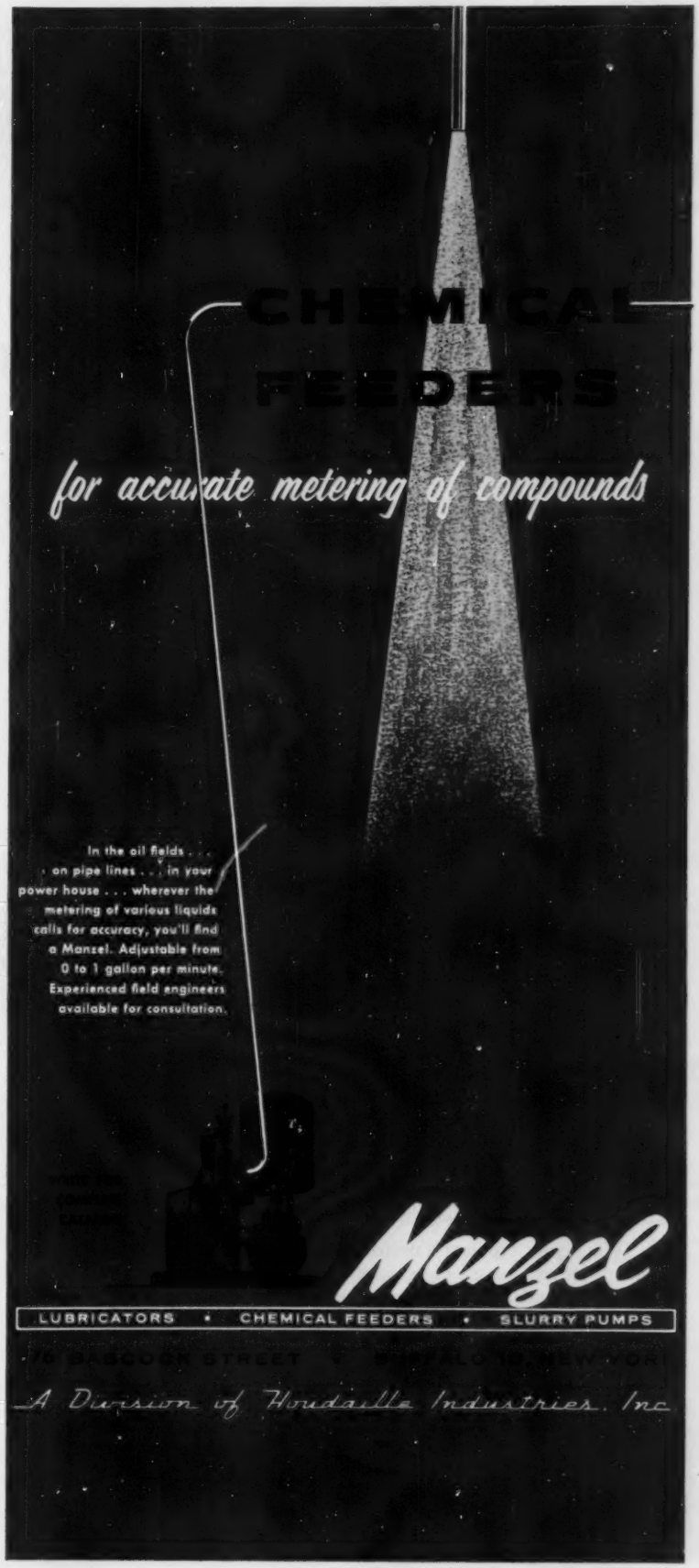
steel check valves. The cone-type valve has a rated flow capacity from 1.2 to 29.0 gpm and ambient temperature range from −65 to 160 F. **Aircraft Products Co., Tact-air Valve Div.**, 300 Church Rd., Bridgeport, Pa.

Circle 741 on page 19

Miniature Capacitors

perform at 200 C without derating

Metallized Teflon capacitors have high performance characteristics at elevated temperatures. Typical performance characteristics at 200 C include: Power factor less than 0.0005; insulation resistance greater than 10^9 ohms; capacitance change of 1 per cent over repeated temperature cyclings from −55 to

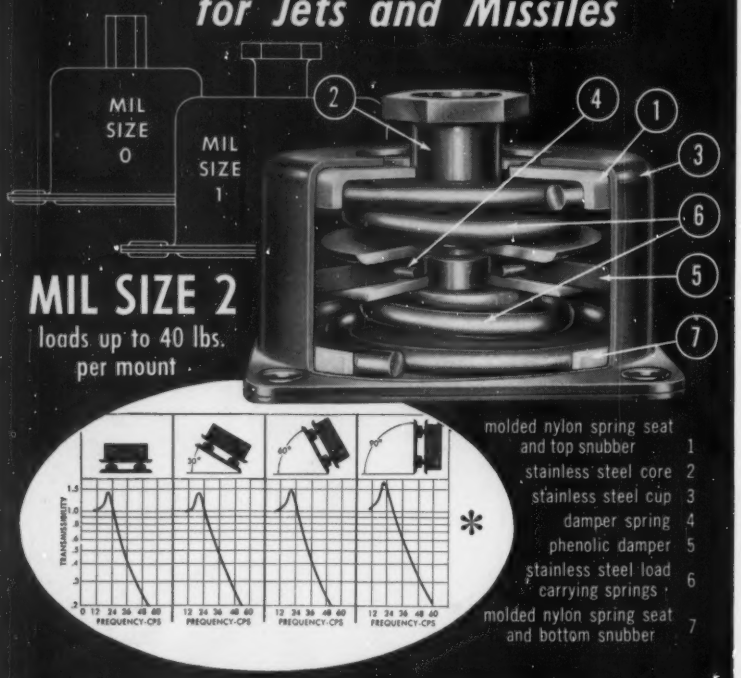

CHEMICAL
FEEDERS
for accurate metering of compounds
In the oil fields . . . on pipe lines . . . in your power house . . . wherever the metering of various liquids calls for accuracy, you'll find a Manzel. Adjustable from 0 to 1 gallon per minute. Experienced field engineers available for consultation.
Manzel
LUBRICATORS • CHEMICAL FEEDERS • SLURRY PUMPS
A Division of Houdaille Industries, Inc.

Circle 510 on page 19

NEW

ALL-ANGL BARRY MOUNT

for Jets and Missiles



NOW AVAILABLE in PRODUCTION QUANTITIES

Gives shock and vibration isolation where MIL-spec mounts won't work

- in every attitude of flight or launching
- under sustained high-g acceleration
- at high amplitudes of vibration input
- during severe shock conditions
- at high vibration frequencies

* These curves show why ALL-ANGL Barry Mounts really work through all attitudes. Data Sheet 57-02 gives detailed specifications. Write now for your copy.

ALL-ANGL BARRY MOUNTS are meeting the tougher requirements for shock and vibration isolation in such high-performance aircraft and missiles as North American Aviation's F-100 Super Sabre, Convair's supersonic F-102A, Martin's MATADOR, and in others still classified *top secret* — giving reliability protection where failure cannot be tolerated. "Only ALL-ANGL Barry Mounts gave effective isolation . . ." is the way their performance in one of today's hottest fighters is described.

When your problem is protection under the tough, complex requirements of jet and missile flight, your answer is ALL-ANGL Barry Mounts. For recommendations, call your nearest Barry Sales Representative.

Barry's new Western Division, in Burbank, California, offers fast, on-the-spot design and prototype service, and production of special systems.

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BARRY B MOUNT

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

722 PLEASANT STREET, WATERTOWN 72, MASSACHUSETTS

New Parts

200 C; low dielectric absorption; and self-healing properties which show no performance deterioration under 1000 hr load-life at 200 C and 140 per cent rated voltage. Units are hermetically sealed in metal cans. **Balco Research Laboratories,** 49-53 Edison Place, Newark, N. J.

Circle 742 on page 19

Subminiature Terminals

are Teflon insulated

Four stand-off and five feed-through Trinseel subminiature Teflon terminals provide capacitances ranging from 0.35 to 0.75 with flash-over points of better than 500 v ac. Service ratings include

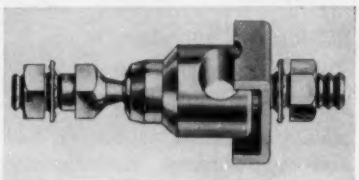
60 cps to 30,000 mc frequencies, temperature range of −450 to 500 F. Sizes range from 0.148 to 0.218-in. in diameter, with 0.040-in. diam pins. Terminal characteristics are based on TSI Teflon, an electronic grade fluorocarbon. The one-piece terminals allow rapid installation. **Tri-Point Plastics Inc.,** Electronics Div., 175-177 I. U. Willets Rd., Albertson, L. I., N. Y.

Circle 743 on page 19

Ball Joint

resists over 250 lb of force

Type EC ball joint has ball socket located in the same unit as the cross-drilled hole to provide added



wall thickness. Ball stud with a short neck enables more than 250 lb of force to be applied on the unit. Swivel construction is assembled with grease-resistant neoprene washer to cushion movement

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in design

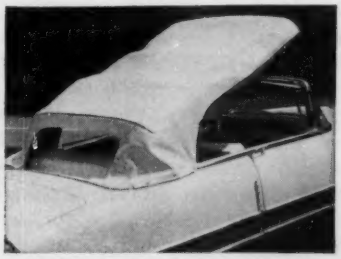
Neoprene boot and seal help simplify design of new helicopter's rotor system

Hypalon®-coated convertible tops resist sunlight, weathering, discoloration

Longer service life and far easier maintenance are the advantages of HYPALON-coated convertible tops. Coatings of this new Du Pont synthetic rubber resist weathering . . . stay flexible at temperature extremes. They permit a wide variety of colors for the tops, too. HYPALON can be compounded in a complete range of durable, light-stable colors that stay bright for years.

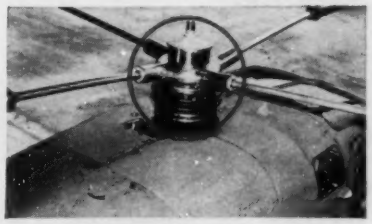
These tops don't soil readily, but when they do, they're easily cleaned with soap and water. The reason: HYPALON doesn't depend on plasticizers for flexibility . . . so no sticky plasticizer oozes to the surface in hot weather to pick up dirt.

This is just one of many commercial applications of HYPALON. Other products, such as conveyor belts, take advantage of the heat resistance of HYPALON. It withstands hardening at elevated temperatures (250°-350°F.). And hose resists strong oxidizing chemicals . . . jacketing for wire is practically ozoneproof . . . when made with HYPALON. From coatings to molded parts, HYPALON offers you properties that assure extra-long service under extreme exposure conditions. Why not get full details? Just mail the coupon below.



RAISING AND LOWERING of the convertible top produces no cracks in the durable HYPALON coating. It resists flex cracking . . . stays flexible and firm despite years of outdoor exposure.

Circle 512 on page 19

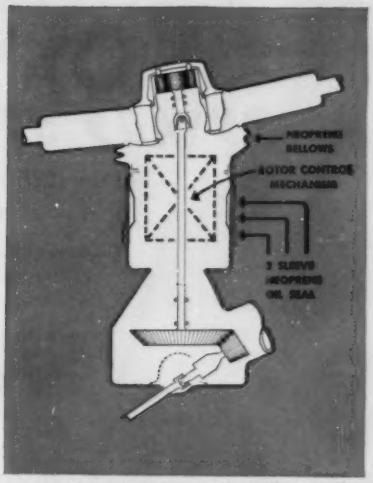


NEOPRENE SPECIFIED FOR RESISTANCE TO OIL, WEATHERING, TEMPERATURE EXTREMES

A step forward in helicopter design is achieved by a new rotor system which has some 1,200 fewer parts than contemporary designs. Doman Helicopters, Inc., Danbury, Conn., claims that maintenance time is slashed by 75%. As many as eight manhours of maintenance for each flight hour have previously been required.

The unique feature of the helicopter is that its rotor hub can be tilted in any direction. To make the hub tiltable, the designer had to have a flexible housing for the rotor control mechanism. He specified neoprene. The upper part of the housing is a neoprene bellows, which serves not only as an enclosure, but also as an annular universal joint through which the control mechanism is driven. The bellows has a ¼-inch wall thickness and is designed for torsional rigidity and vertical flexibility. Lower part of the housing is a three-sleeve labyrinth oil seal also made of neoprene.

Neoprene was chosen for its combination of properties. On the outside, the housing needs neoprene's resistance to sun, weather and ozone. On the inside, the housing material must withstand the hot oil (225°F.) that bathes the entire rotor control mechanism.



NEOPRENE BELLOWS permits entire rotating hub of helicopter to be tilted in any direction . . . provides protection in all positions. Neoprene labyrinth oil seal bellows eliminates multiple grease fittings.

This oil-bath lubrication system has some advantages of its own. It has eliminated grease fittings and has simplified maintenance. The manufacturer says mechanics can peel back the bellows and seal and dismantle the gears and drive shaft within 20 minutes.

MANY DESIGNERS have found neoprene the ideal answer for a resilient material that must resist flame, flex cracking, chemicals . . . or any of the many exposure conditions that an ordinary rubber product cannot withstand. Why not get all the facts about neoprene? Just mail coupon below for complete information.

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HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

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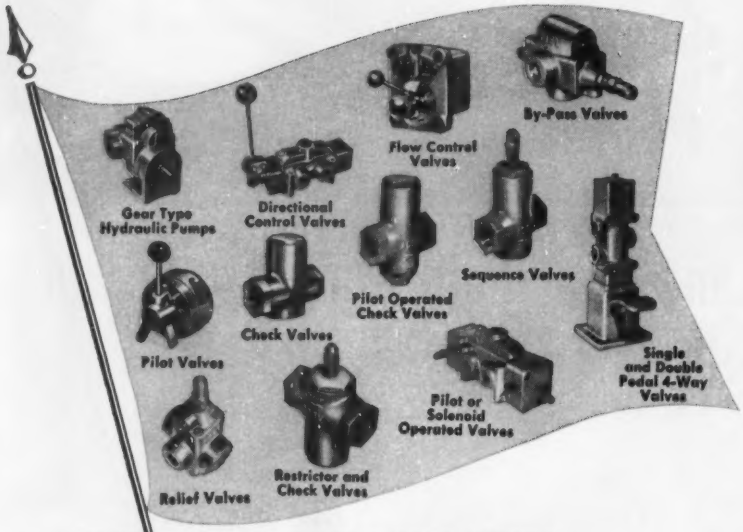

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Air-Draulic Equipment Company
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UTAH •
Robert Taylor & Sons
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WASHINGTON •
Haskel Engineering & Supply Co.
Seattle, Washington

Circle 513 on page 19

New Parts

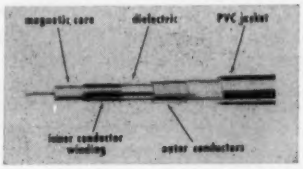
and maintain proper tension. Spring clip allows rapid adjustment over great length. Nut, lockwasher and spring clip are permanently assembled on the unit. Present applications include use in automatic transmissions, heating, ventilating and air control. **J. J. Tourek Mfg. Co.**, 1901 S. Kilbourn Ave., Chicago 23, Ill.

Circle 744 on page 19

Delay Cable

has low losses and good transmission fidelity

Type HH-1600 delay cable is built around a flexible, low-loss magnetic core which provides very high unit delay with low losses and good transmission fidelity. Delay is 1.0 microsecond per ft, impedance, 1700 ohms, and insertion loss, 0.3



db for a delay of 1.0 microsecond. Operating temperature range is from −40 to 85 C. Cable has a diameter of 0.28-in. and is very flexible. It is useful in complex electronic equipment and in color TV receivers. Cable is furnished in calibrated lengths as calibrated delay lines, with molded vinyl endcaps, with delays from a fraction of 1 to 100 microseconds, or as bulk cable. **Columbia Technical Corp.**, 61-02 31st Ave., Woodside 77, N. Y.

Circle 745 on page 19

Galvanizing Treatment

is applied to any clean metal surface

Galvoplate treatment for cold galvanizing is a metallic coating of 95 per cent pure zinc base. Combining with the base metal, it sets up electrical continuity, offers cathodic protection and can be applied with either a brush or spray gun to any clean metal surface. No special pretreatment is required. It can also be used to arrest corrosion already started. The

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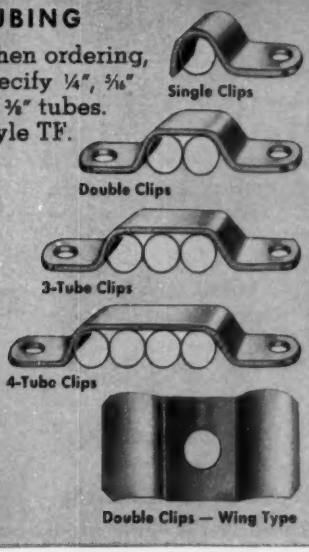
When ordering, specify ¼", 5/16" or ⅜" tubes. Style TF.



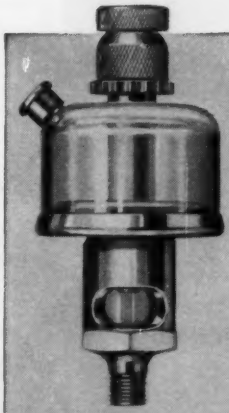
Single Clips

Double Clips

3-Tube Clips

4-Tube Clips

Double Clips — Wing Type



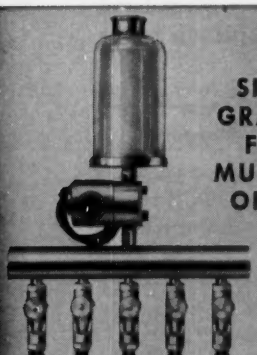
SIGHT GRAVITY FEED OILERS

Rate of oil flow regulated by needle valve, directly observed through sight glass in stem.

Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

GEAR CASE GAUGES

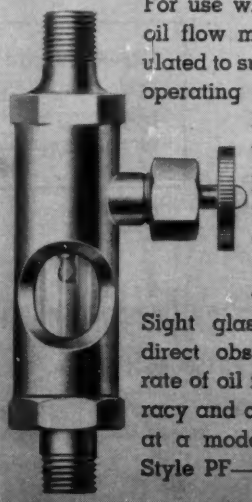
This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.



SIGHT GRAVITY FEED MULTIPLE OILERS

This one unit replaces 3 to 8 individual oilers. Maximum practicality in a small central lubrication system. Positive cut-off during idle periods. Individual vibration-proof needle valve adjustments. With solenoid control (Illustrated): Style MDS—No. 4685-A. Without solenoid: Style MD.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

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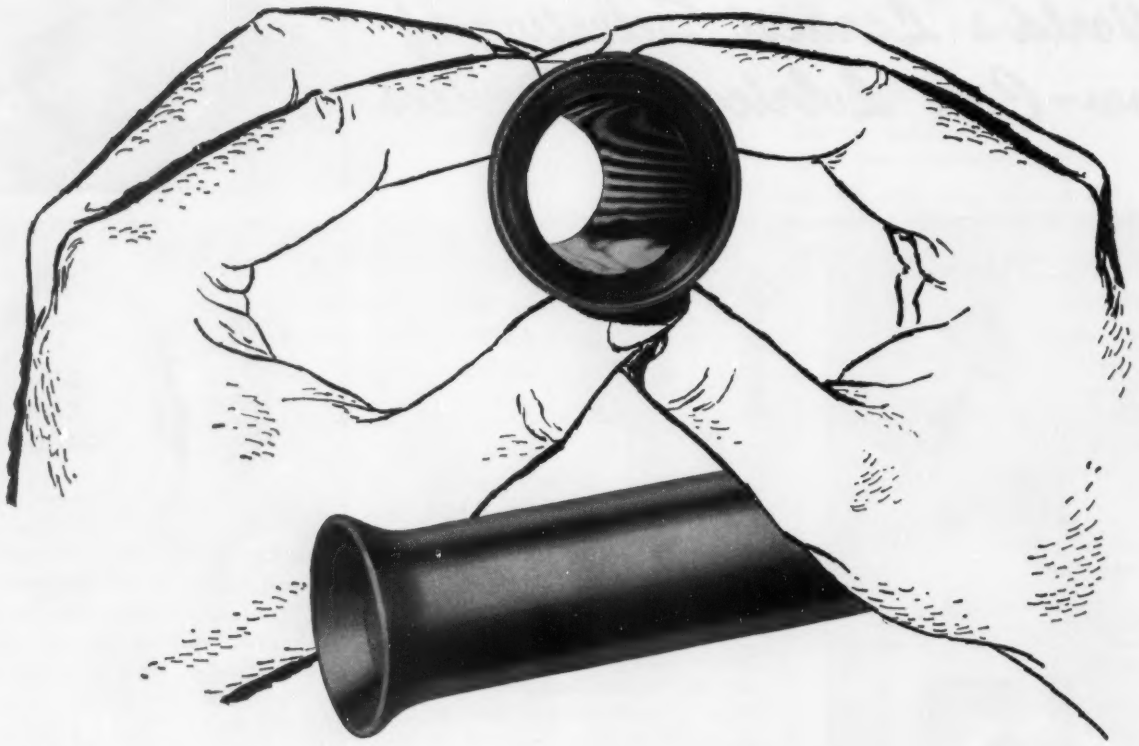
Clip this page for handy "rough reference"

Circle 514 on page 19

Cut Hydraulic Flow Resistance . . . Specify HYDRALUSTER the Only "rifle-barrel" Tubing



AXIOM: The smoother the surface, the less resistance offered. And here you see the inside of a section of HYDRALUSTER tubing . . . photographic proof of a super-smooth surface.

Hydraluster is a cold-reduced, carbon steel tube for hydraulic and diesel application. Its exclusive finish is the reason that systems using Hydraluster are developing the highest rates of power efficiency and reaction time.

Hydraluster has other advantages to offer the Original Equipment Manufacturer. Hydraluster is highly resistant to oxidation, even under the conditions imposed by the newest, high-speed fluids. The result is greatly improved maintenance records. And the bright exterior finish of the tubing adds to the appearance and sales appeal of precision machinery.

Produced in standard hydraulic sizes, Hydraluster is a premium tube sold at standard hydraulic tubing prices.

SAMPLES and SPECIFICATIONS: Make the "rifle-barrel" test yourself. Your name on a company letterhead will bring specifications, literature and a sample of Hydraluster by return mail.

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Circle 515 on page 19

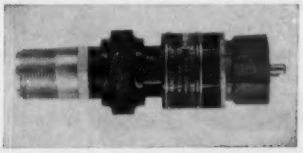
material provides a smooth, hard surface that is abrasion-resistant and flexible. It makes an excellent base for decorative finishes, and any size product can be treated. **Danton Corp.**, 339 Auburn St., Auburndale 66, Mass.

Circle 746 on page 19

Miniature Clutch

in wide range of sizes has positive drive

Reliance miniature clutch makes possible the positive engagement or disengagement of any or all parts of power transmission drive installations, such as tachometer



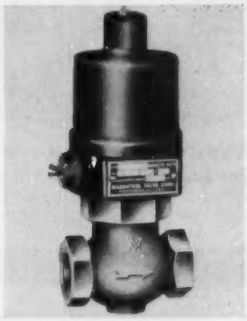
or counter drives. It is equipped with positive drive, rather than depending on friction to hold it secure. Several models are available, each with end fittings designed for insertion at any point in power transmission installations. **Barbour-Stockwell Co.**, Cambridge, Mass.

Circle 747 on page 19

Solenoid Valve

is rated to 300 psi and has full-port capacity

Type AR solenoid valve with full-port capacity automatically controls water, brine, solvents, gas



and air. Having a tight shut-off when solenoid is energized, valve is also suitable for control of vacuum lines. Cast of high-pressure valve bronze, it has screwed ends

(*Continued on Page* 210)

BARBER-GREENE Depends on Baldor Streamcooled Motors to Power Its Asphalt Batch Plants & Belt Conveyors!

Despite the most torturous use, plus the constant hazard of dust and dirt, Baldor Streamcooled Motors keep famous Barber-Greene equipment operating at top efficiency, day after day.

This kind of superior performance has earned Baldor an enviable reputation among many outstanding heavy equipment manufacturers.

If you have a power problem that demands the utmost in motor performance, perhaps Baldor can help you, too!

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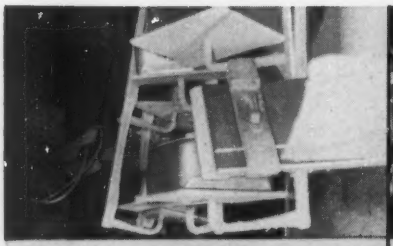
Circle 516 on page 19



Reynolds can paint entire parts a solid color, mask and paint or do paint filling in combination with mechanical finishing to supply practically any desired texture or highlighting effect.

Part of a battery of new high speed buffing equipment available at Reynolds. Scratch-brushing, satin finishing, highlighting, embossing and other mechanical finishes are also available.

Alodine system at Reynolds is adaptable to immersion, spray or brush type finishing. Etching, brightening and other chemical finish treatments are also available at Reynolds.

for greater design freedom and finer "finished" aluminum products ...use the new, vastly expanded

REYNOLDS

FINISHING FACILITIES

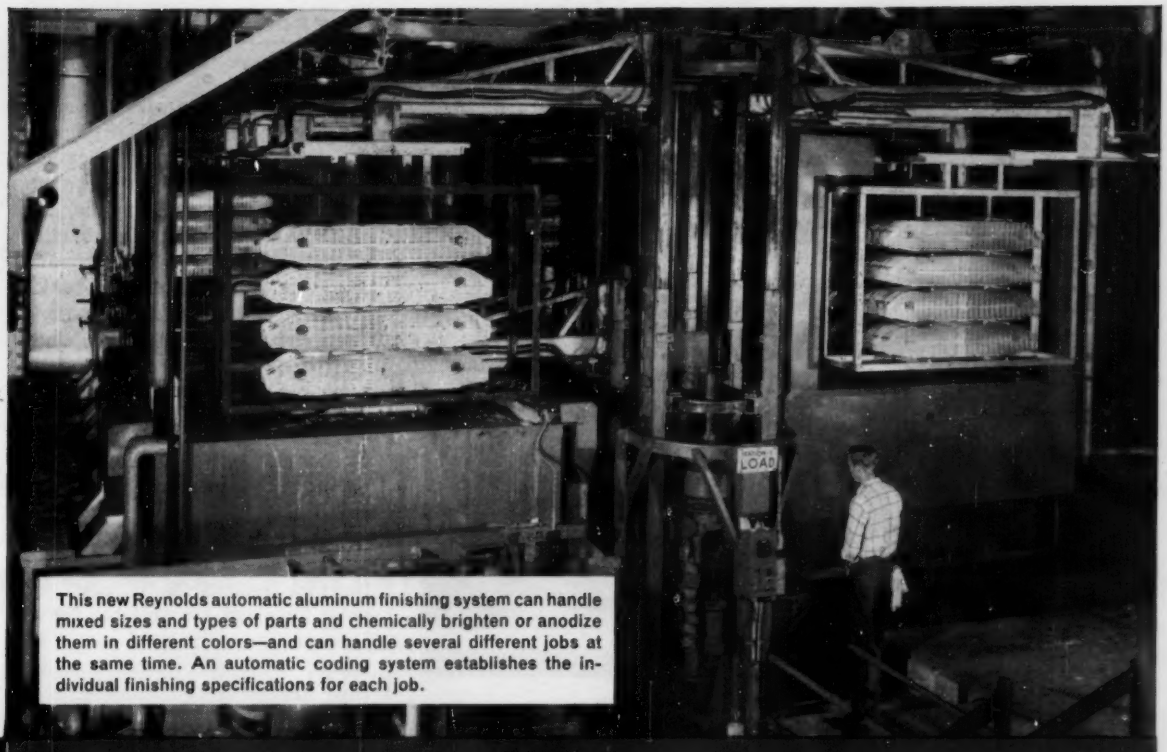
For the magic touch of gleaming clear and color anodized finishes—and for many types of mechanical, chemical and paint film finishes—you can depend on finishes from Reynolds to add sales appeal and value to the aluminum products you design.

Reynolds multi-million dollar investment in finishing equipment—some of this equipment illustrated on these pages—assures you the finest aluminum finishing facilities available anywhere. These recently expanded facilities permit new and greater flexibility in your design thinking. And these facilities are backed by Reynolds years of technical experience with practically every finishing process and technique applicable to aluminum plus Reynolds quality control from mine to finished part.

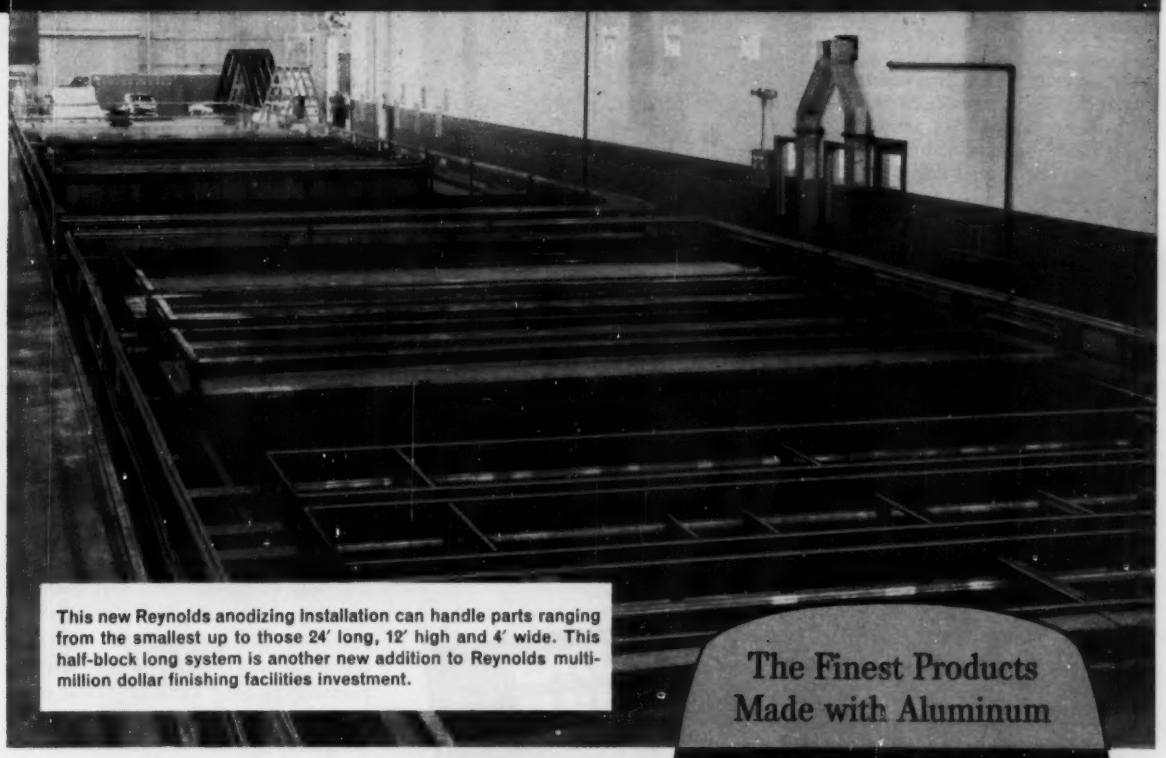
For full details on the finishing and fabricating facilities available, call the Reynolds Office listed under "Aluminum" in your classified telephone directory or write *Reynolds Aluminum Fabricating Service, 2061 South Ninth Street, Louisville 1, Ky.*

See "CIRCUS BOY", Reynolds new dramatic series, Sundays on NBC-TV

REYNOLDS ALUMINUM FABRICATING SERVICE



This new Reynolds automatic aluminum finishing system can handle mixed sizes and types of parts and chemically brighten or anodize them in different colors—and can handle several different jobs at the same time. An automatic coding system establishes the individual finishing specifications for each job.



This new Reynolds anodizing installation can handle parts ranging from the smallest up to those 24′ long, 12′ high and 4′ wide. This half-block long system is another new addition to Reynolds multi-million dollar finishing facilities investment.

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

BLANKING · BRAZING · DRAWING · EMBOSSING

FINISHING · FORMING · RIVETING

ROLL SHAPING · TUBE BENDING · WELDING

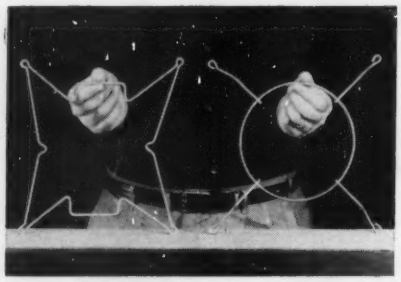
Circle 517 on page 19

"Simplicate it... and add more Lightness"

This famous saying by one of America's leading research engineers is the key to much of today's design progress. Sometimes all it takes is the right twist—in Wire. Here are a few specific examples from "Wire Goods Headquarters" . . .

This simple twist saved $1,530.00 in one year

Manufacturer's wire motor mount design called for 26 bends in a 28"-long wire . . . almost impossible to hold tolerances. Titchener suggested simplified design at right: a ring, 4 support wires, 4 welds—that's all. Estimated saving 10.2c per piece.

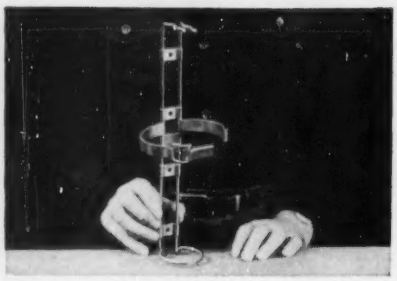


This simple twist saved 75¢ per unit

By combining a motor mount and fan guard in one wire-and-strip assembly, Titchener eliminated expensive pipe frame-work and heavy stampings, reduced noise level, and saved 75c per unit over the former design.

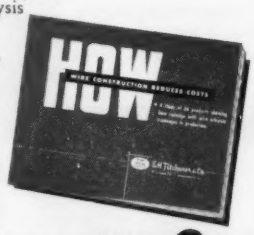
This simple twist cut weight in half

Extinguisher wall bracket redesigned by Titchener eliminates 16 rivets and 3 stampings. Improved design is stronger, more serviceable—weighs half as much—gives substantial savings in manufacturing and material costs.



Wire construction and design assistance by Titchener may be able to solve your cost problem, whatever your product. Our engineers will be glad to help you find out. Merely send prints or samples. No cost or obligation for our analysis and recommendations.

Free Case History Booklet. Shows before-and-after illustrations of 36 products and parts which have been redesigned in wire. Gives specific cost savings and product improvements accomplished. This booklet can be a storehouse of tips and ideas for design and purchasing men.



WIRE GOODS Headquarters.

E.H. Titchener & Co.

61 Clinton St., Binghamton, N. Y.

New Parts

(*Continued from Page* 207)

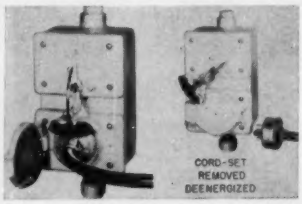
and is available in sizes from ½ to 3 in. with pressure ratings to 300 psi. In opening, a quick-acting spring insures positive action. In high-pressure applications, line pressure assists spring in providing instantaneous opening. Removable operating assembly permits quick disassembly for inspection without disturbing fluid or electrical lines. **Magnatrol Valve Corp.**, 73 Fifth Ave., Hawthorne, N. J.

Circle 748 on page 19

Safelock Receptacles

for outdoor weatherproof service

Safelock receptacles in cast condulet housings are suitable for all outdoor extension-cord sets for lamps, drills and tools. Cord set caps are securely locked in position and cannot be removed until release lever is manually tripped, automatically de-energizing sockets. Heavy-duty, waterproof, sealed mercury switch contactors assure high current-carrying capacity. **Industrial Automation Corp.**, 2415 W. Montrose Ave., Chicago, Ill.



Circle 749 on page 19

Floating Anchor Nut

is fuel-resistant and self-sealing

F 1968 fuel-resistant, self-sealing floating anchor nut is for use in fuel tanks, pressurized cabins, cockpits and other areas where positive sealing against gases and liquids is required. It contains an integrally molded rubber seal which provides tolerance-free sealing and resists aircraft fuels, oil, salt water and most organic solvents. Temperature range of the seal is −80 to 225 F. Nut element floats independently of seal to accommodate misalignment in

Circle 518 on page 19

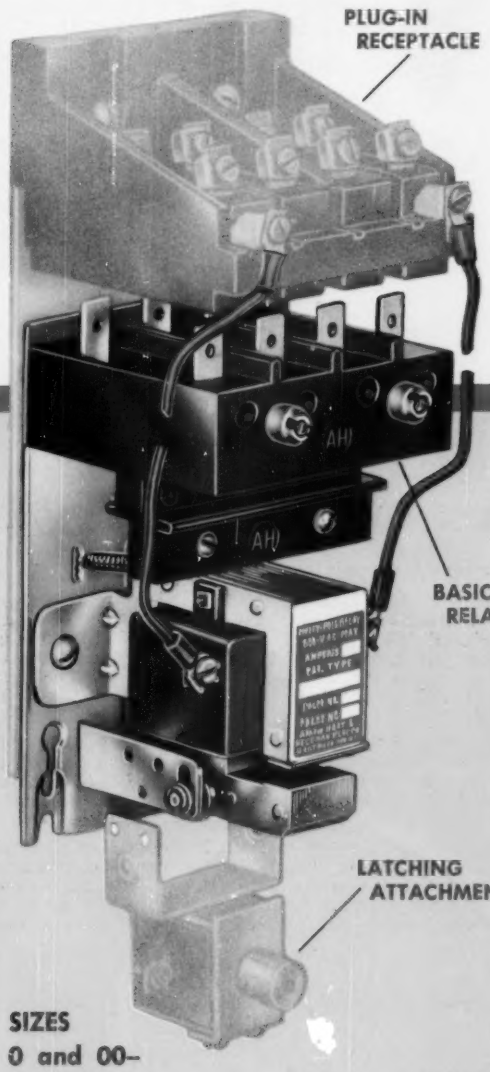
Circle 519 on page 19→

Announcing

THE COMPLETE MACHINE TOOL RELAY

by ARROW AH HART

A NEWER, FINER ADVANCED-DESIGN COMPONENT THAT DOES MORE DIFFERENT TYPES OF JOBS . . . *BETTER!*



SIZES
0 and 00–
600 V AC

Check these features for

ADAPTABILITY —

- **CONTACTS QUICKLY CONVERTIBLE** . . . from normally-open to normally-closed, no tools needed. No loose parts. Exclusive center positioning device guards against contact damage while converting.
- **OPTIONAL LATCHING ATTACHMENT** . . . *another A-H exclusive,* allows quick conversion of contactor to latching type. This attachment is quickly changed from **latch-in** to **latch-out** operation or **latched-in and out.**
- **PLUG-IN/SCREW-TYPE TERMINALS** . . . can be used for plug-in and screw-type as desired.
- **MOST COMPLETE LINE AVAILABLE** . . . Removal of Terminal Screws from Standard Relays converts use to plug-in relays. In 2, 3, 4, 6 or 8 poles . . . in IMP (Interchangable Pole) or FMP (Fixed Pole) types. The **BASIC RELAY** is suitable for use by itself.

FAST, EASY INSTALLATION and SIMPLE MAINTENANCE —

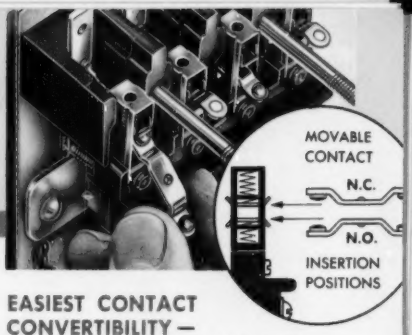
- **OPTIONAL PLUG-IN RECEPTACLE** . . . minimizes down-time on high-output machines, since entire contactor unit can be replaced in minutes without disturbing wiring.
- **EXCLUSIVE FRONTAL SWING-OUT** . . . permits fast, easy removal of entire coil.
- **EXPOSABLE MAGNET POLE FACES** . . . for inspection or cleaning.
- **SELF-CONTAINED CONTACT CAGE** . . . with no loose springs, screws or other parts to get lost.
- **MORE COMPACT SIZE** . . . allows easy location, leaves more space for easier wiring.
- **SEPARATE TERMINALS for CONTROL CIRCUITS AND COILS** . . . without using extra poles.

EFFICIENT, DEPENDABLE OPERATION —

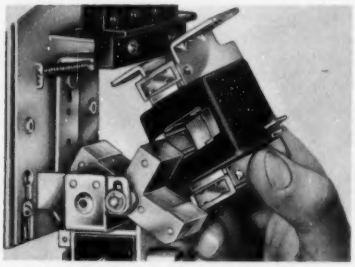
- **ALL CURRENT-CARRYING PARTS SILVER PLATED** . . . for highest capacity and minimum heating.
- **FRICTION-FREE, DUST-RESISTANT OPERATING MECHANISM** . . . with positive, fail-safe action.
- **ABSOLUTE ALIGNMENT OF PLUG-IN PRONGS** . . . insured by combined receptacle and mounting plate.
- **CONTACTS and GUIDING FRAMES** . . . of special heat-tempered materials to minimize wear and assure smooth action.
- **HIGH-EFFICIENCY SOLENOID MAGNET and MOLDED, LOW-WATTAGE COILS.**

PLEASE TURN THE PAGE FOR ADDITIONAL INFORMATION

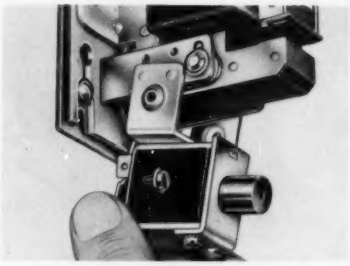
Greatest Versatility
ever offered in a SINGLE RELAY DESIGN!



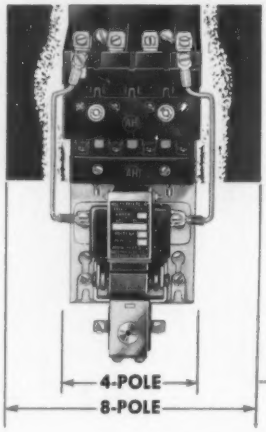
EASIEST CONTACT CONVERTIBILITY — *No tools needed — No loose parts to get lost.*



FASTEST COIL ACCESSIBILITY — *Simply remove 2 screws, swing to front and lift out!*



HANDIEST LATCHING ATTACHMENT — *Quickly converts any of these contactors to latching type — attachment simply converted* in the field *— latch-in, latch-out, or latched both ways as desired.*

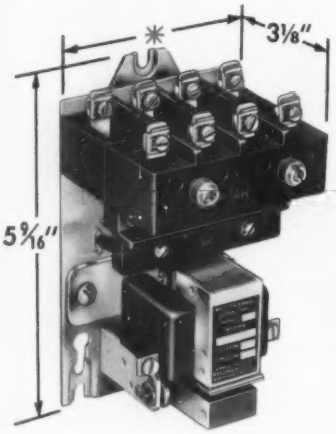


Available

- in AC and DC types
- with 2, 3, 4, 6 or 8 poles
- SIZE 00 (10 Amp) or SIZE 0 (15 Amp)
- IMP (Convertible and Renewable) Type or FMP (Fixed and Renewable) Type
- with Optional Plug-In Receptacle— Type IMP-100 Series
- with Optional Latching Attachment — Cat. #IMP-11 (Specify Coil Voltage)

COMPARATIVE WIDTHS

4-POLE and 8-POLE RELAY with OPTIONAL PLUG-IN RECEPTACLE and LATCHING ATTACHMENT



* SEE TABLE

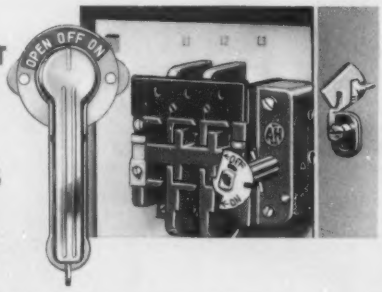
INTERCHANGEABLE MULTI-POLE RELAYS

No Other Relay Offers This Versatility In 2, 3, 4, 6 and 8 Poles	Size 00 10 Amp	Size 0 15 Amp	Applicable in Field	Applicable to Standard Relay
Relay—Type IMP CONVERTIBLE and RENEWABLE Contacts	X	X		
Relay—Type FMP FIXED and RENEWABLE Contacts	X	X		
Optional Plug-In Receptacle	One for both		X	X
Optional Latching Attachment	One for both		X	X

No. of Poles	2 to 4	6	8
Width	3"	4½"	6"

Receptacle adds 2¼" to height and ½" to depth. Latch adds 1¼" to height.

ARROW-HART TYPE "RAD" DOOR DISCONNECTS MEET JIC STANDARDS



the ultimate in —

SAFETY — ALWAYS-VISIBLE CONTACTS give operator constant visual assurance of safety. EASY-TO-SEE HANDLE INDICATORS clearly show "On", "Off", and "Open" positions. SAFE "OFF" FEATURE prevents opening door until handle is purposely turned to "Open" position. LINE COVER prevents accidental contact with live wires.

MINIMUM MAINTENANCE — RUGGED, BUTT-TYPE SILVER CADMIUM OXIDE CONTACTS provide highest possible weld resistance. CONTACTS EASILY REPLACEABLE without disturbing wiring. DISCONNECT HANDLE is oiltight.

EASY INSTALLATION — Both 30 and 60 amp sizes have identical mounting dimensions, making standardization easy. Mounting requires only 3 small holes and 2 screws. Easy-locating feature for hole location. Three adjustable operating shafts take care of variations in panel depth.

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 Hawthorn Street, Hartford 6, Connecticut
MOTOR CONTROL DIVISION

Please send me complete engineering data on:

☐ A-H Type "IMP" and "FMP" Contactors
☐ A-H Type "RAD" Door Disconnects

NAME _____
POSITION _____
COMPANY _____
CO. ADDRESS _____
CITY _____ ZONE _____ STATE _____

ARROW AH HART

Quality since 1890

WIRING DEVICES • MOTOR CONTROLS • ENCLOSED SWITCHES • APPLIANCE SWITCHES

assemblies. Rigid construction provides increased resistance against deflection under push-out conditions and assures a tight, con-

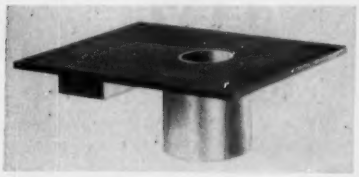
tinuous seal against gas and liquid pressures encountered in aircraft applications (−14 to 50 psi). Push-out and general strength values exceed military specification requirements. **Kaynar Co.**, Kaylock Div., Box 2001, Terminal Annex, Los Angeles 54, Calif.

Circle 750 on page 19

Proximity Pickup

for counting purposes has detachable cable

Model 4920-AN hollow coil proximity pickup, designed for use with Electro proximity transducer systems, is well suited for counting small metal parts such as screws, nuts, washers and bolts. It utilizes a hollow phenolic table around



which sensing coil is wound. As a high-frequency, carrier-operated transducer, it senses aluminum, brass, copper, iron and steel. Coil, connected by a cable to a control unit, causes the control unit to generate dc voltages or operate relays. Pickup is available in 15 sizes from ¼ to over 3 in. in diameter. **Electro Products Laboratories Inc.**, 4500 Ravenswood Ave., Chicago 40, Ill.

Circle 751 on page 19

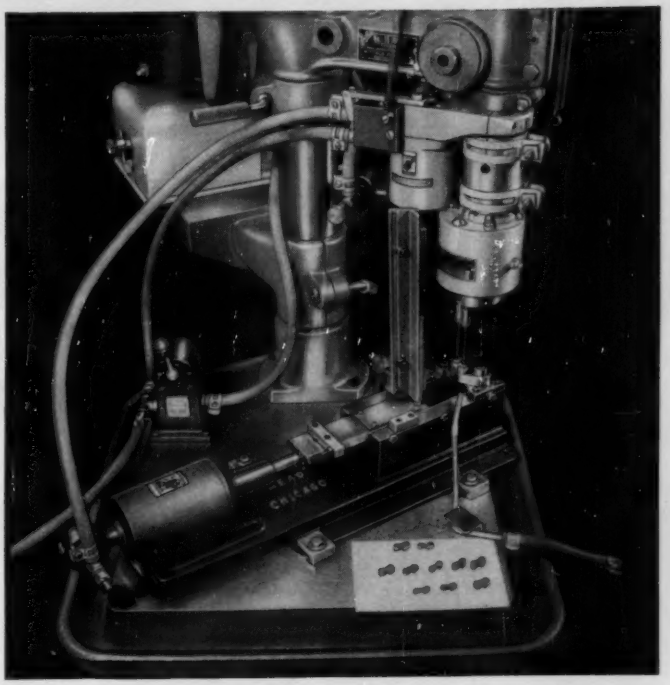
Pickup Control Unit

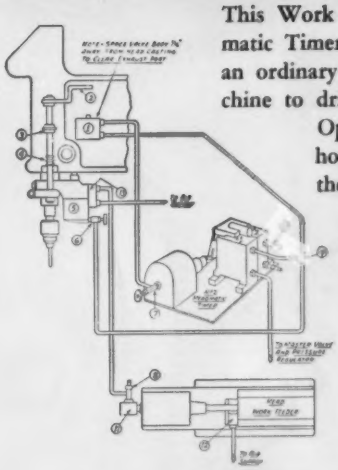
operates at 10 cps and has ac plug at output

Model 4901-RAC proximity-pickup control unit permits the use of a standard electrical plug rather than a microphone connector at the

(Continued on Page 216)

AUTOMATION WITH AIR POWER





This Work Feeder, with the aid of a Meadmatic Timer and Drill Press Feed, transforms an ordinary drill press into an automatic machine to drill twin holes in Chain saw links. Operator merely keeps the vertical hopper loaded—the machine delivers them to the drills, holds them firmly and ejects them when finished. Material is tough alloy steel, ranging in thickness from ⅛" to ¼". Hole spacing is held to .0005" by bushings mounted in plate with micro adjustment. Production is 600 to 900 per hour, depending on thickness.

Write for free illustrated booklet of 44 "Examples in Air Power Automation".

MEAD

MEAD SPECIALTIES COMPANY

4114 N. Knox Ave., Department MD-37, Chicago 41, Illinois

PATHFINDER IN AIR POWER AUTOMATION

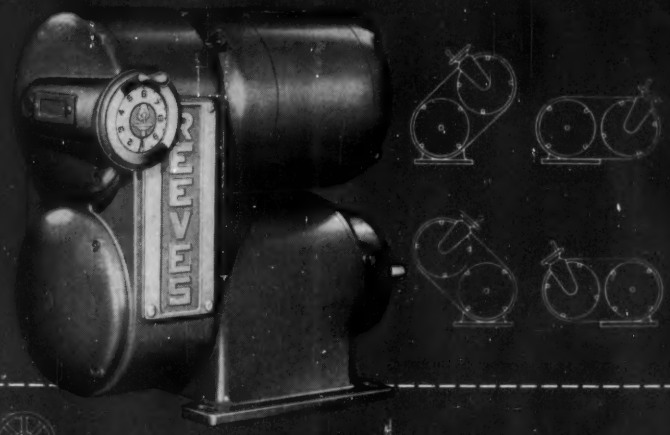
Circle 520 on page 19

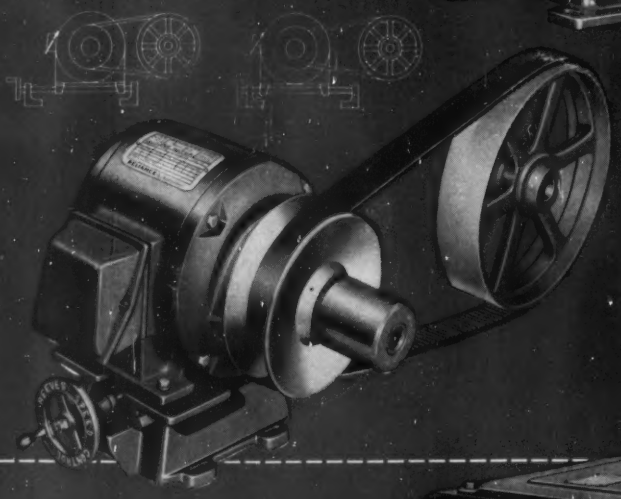
REEVES®

the one name for all mechanical variable speed!

REEVES Vari-Speed Motodrive

A complete power package . . . choose from over 100 assemblies in vertical, horizontal or 45° models . . . ¼ to 40 hp. . . . 2:1 to 10:1 speed ratios from as low as 9 rpm. to a maximum of 4660 rpm! Assemblies available in standard, totally-enclosed or splash-proof enclosures.



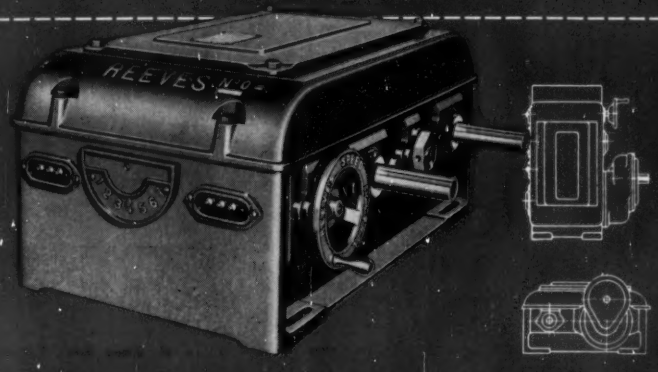


REEVES Vari-Speed® Motor Pulley

The low cost answer to variable speed advantages! Choose from 8 sizes . . . ½ to 15 hp. . . . 1.75:1 to 4:1 speed ratio. Easy maintenance and long life assured . . . just 5 main parts. REEVES "close-grooving" lubrication insures free sliding disc for easy speed changes. Standard or countershaft motor bases.

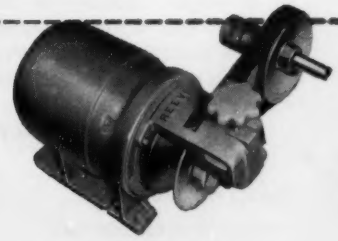
REEVES Variable Speed Transmission

Vertical or horizontal types—in open frames or enclosed cases—straight, countershaft or reducer models. Fractional to 87 hp. . . . 2:1 to 16:1 speed ratios. "Internals only", without frame or case, also available.



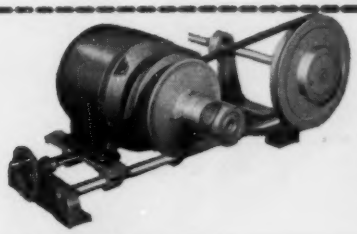
● The *complete line* in the industry is REEVES . . . adjustable speed drives and speed control for applications from ⅛ to 87 hp! The *proven* name is REEVES . . . years of trouble-free service in hundreds of thousands of installations—every industry! The *original* variable speed drive, REEVES is still the leader in its field!

Incorporate variable speed into the machines *you* design: widen the work range of the machines; insure your designs against early obsolescence; add the many operating advantages of accurate, instant speed control. Your REEVES representative—with wide and varied experience—will be glad to work with you for the *best* application . . . *best* results!



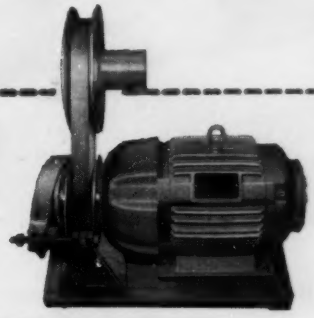
REEVES Flexi-Speed®

Two sets of adjustable discs with convenient shifting mechanism. Provides flexibility, economy to your equipment . . . easy to install. ½, ¾ and 1 hp. with 8:1 speed ratio.



REEVES Jr. Motor Pulley

Simplest form of variable speed control. 5 sizes from ⅛ to 1½ hp. capacity . . . ratios up to 2.75:1 in a speed range from 135 to 1965 rpm. Standard or countershaft bases for standard motors.



REEVES Vari-Spin®

A mill tested and proved unit to increase spinning efficiency and frame flexibility. 500 to 1450 rpm. range. Change speeds *with spinning frame in operation* . . . get required speed—in seconds!

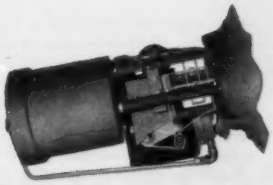
REEVES CONTROLS

Manual

Basic REEVES control on all units. "Speedial" handwheel, extended handwheel, hand chain and extended rod controls also available.

***Mechanical Automatic**

For Motodrive, Transmission. Simplest automatic control—requires shifting force sufficient to position control lever of speed changing mechanism.



Automatic (Pneumatic)

Motodrive application only. Cam-compensated design controls output speeds in direct proportion to instrument air signals.

Electric Remote

Push-button stations for single unit or battery of Motodrives, Transmissions or Motor Pulleys. AC or DC . . . full range of current characteristics.

*Also available in hydraulic or pneumatic type.

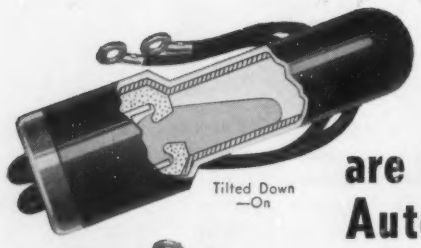
Individual bulletins—complete with rating tables and dimensions—are available for any of the above products by writing REEVES, Dept. H-26b, Columbus, Indiana.

Your REEVES representative will be glad to work directly with you. He's as near as your telephone . . . regional offices in 34 principal cities.

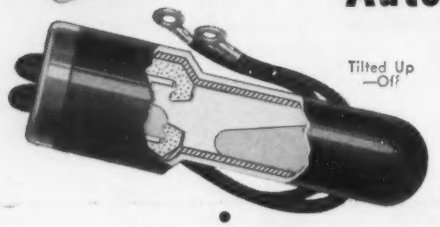
REEVES PULLEY COMPANY

DIVISION OF **RELIANCE** ELECTRIC AND ENGINEERING CO.

COLUMBUS, INDIANA



DURAKOOL Tilt Switches are the Life of your Automatic Controls



This steel-clad Durakool mercury tilt switch has unique construction features that deliver years of trouble-free performance on the most difficult assignments you can find. Operating under sealed-in, pressurized hydrogen gas, it takes 24 hours, fast cycling schedules in stride. 7 sizes, 1 to 65 amperes. Send for Bulletin 525.

MILLIONS OF CYCLES WITHOUT FALTERING

See telephone directory for local distributor, or write.

DURAKOOL, INC.
ELKHART, INDIANA, U.S.A.
700 WESTON RD., TORONTO 9, CANADA

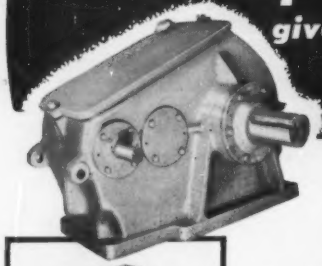
Durakool ALL-STEEL MERCURY Switches

Circle 522 on page 19

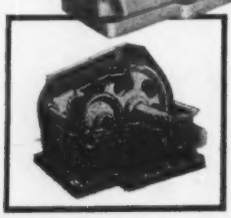
DESIGN ENGINEERS AVAILABLE

Alten engineers are available for your speed reducer problems. Their experience is reflected in thousands of Alten engineered reducers now in operation.
Alten Speed Reducers have heat treated forged steel helical or herringbone gears, mounted on anti-friction bearings, enclosed in a rugged one piece semi-steel case. They have proved their ability to take the load reversals, shock pressures and continuous unattended operation demanded by the oil field industry.

ALTEN Speed Reducers give TOP PERFORMANCE at SENSIBLE PRICES



Alten Speed Reducers are now available on a nationwide basis for industrial users. Ten basic models are suitable for nearly any type base mounting or drive. Sizes range from 1 h.p. to 275 h.p. AVAILABLE FOR IMMEDIATE SHIPMENT.
Complete engineering data—ratios, peak torque, h.p. and features of Alten's exclusive designs are yours for the asking. Why not let Alten solve your speed reduction problems?



Cut away view showing herringbone gear construction—helical type gears are also available.

Designers and Builders of Equipment for Industry

ALTEN FOUNDRY and MACHINE WORKS, INC. Lancaster, Ohio

New Parts

(*Continued from Page* 213)

output. Output is wired for 115 v ac to 60 w through an internal relay. Relay is a single-pole, double-throw type with contacts rated at 5 amp, 115 v ac, noninductive, and operates at speeds to 600 operations per minute. Control unit incorporates 3-pin, AN-type input connectors. Enclosed in a vented hammerloid cabinet, the unit measures 2⅝ x 4⅝ x 8 in. It can be used as a portable device, enclosed in a larger cabinet, or can be mounted and wired in permanently with conduit. **Electro Products Laboratories Inc.**, 4500 N. Ravenswood Ave., Chicago 40, Ill.

Circle 752 on page 19

Induction Motors

from 10 w to 1000 hp for aircraft application

Lightweight induction motors are for aircraft application where size, weight and temperature are limiting factors. Motor illustrated weighs 4.8 lb, is rated 6½ hp, 24,000 rpm, 3 phase, 208 v, 400 cycle. Design features include totally enclosed, explosionproof con-

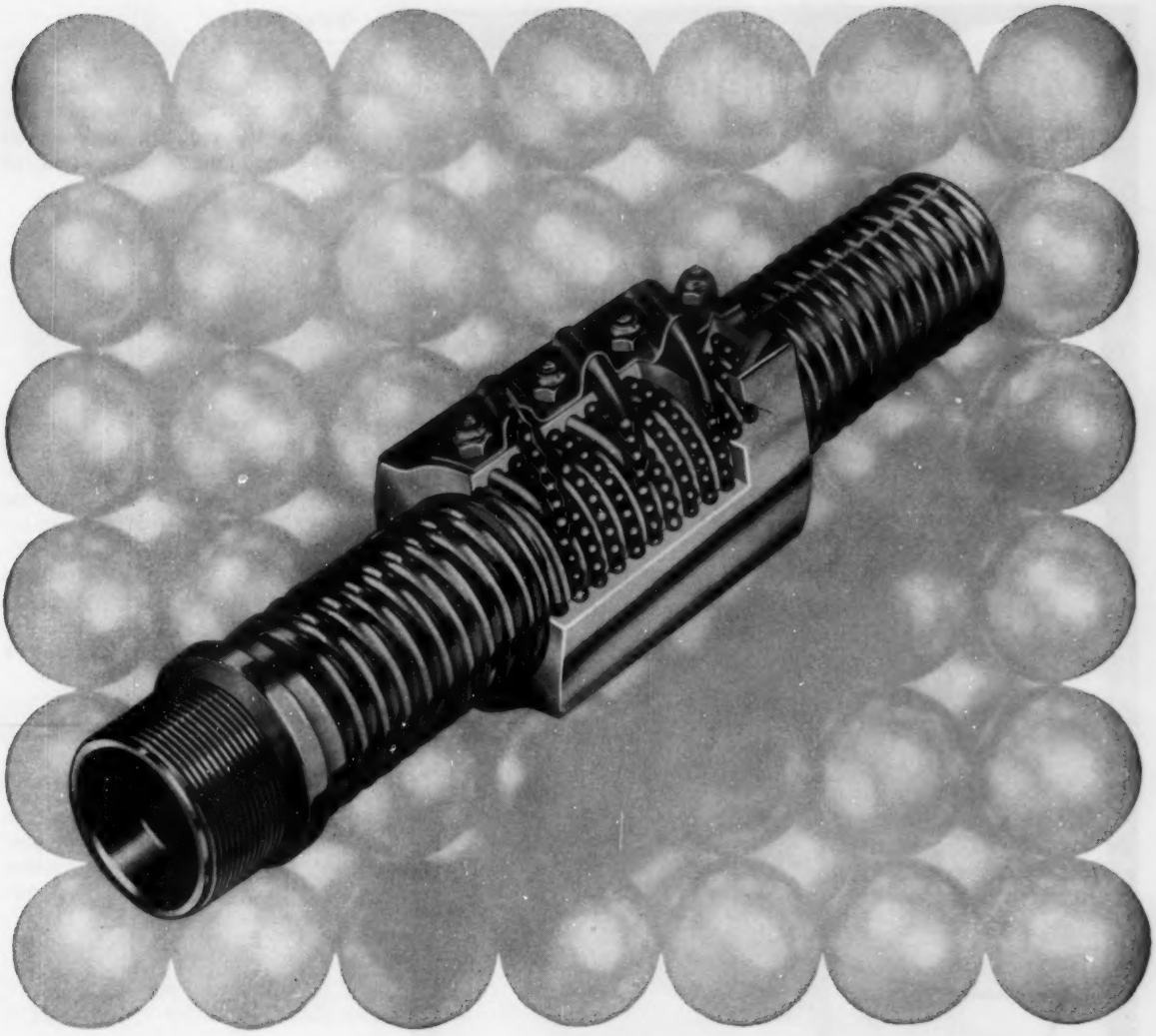
struction, air cooling, environment-free liquid cooling, and precision ball bearings for long life. Available in standard or custom models for power outputs from 10 w to 1000 hp, motors can be provided to operate from standard, special or variable-frequency power supplies. **Task Corp.**, 1009 E. Vermont Ave., Anaheim, Calif.

Circle 753 on page 19

All-Metal Mounting

for pressure-ratio transmitter unit

Met-L-Flex Model 1323 center-of-gravity lightweight mounting for a pressure-ratio transmitter incorporates pressure and electrical connectors as part of the supporting structure. Aluminum and steel throughout, it is a permanent-type mounting unaffected by adverse



how Vacuum Metals' FERROVAC boosts ball bearing screw life up to 400%...

Ball bearing screw assemblies, first used in automobile steering mechanisms, are now found in such critical applications as the actuation of landing gear and control surfaces of aircraft and guided missiles. And it was in tough jobs like these that the assemblies failed in fatigue. Then a leading manufacturer tried vacuum-melted FERROVAC® for the balls – and service life rose as much as 400% over the original life. Here's why...

Vacuum melting improves fatigue properties – It literally sucks gaseous impurities – focal points for fatigue failure – from the molten metal. Vacuum-melted metals are cleaner, purer, tougher. And cleanliness means an added bonus in fewer rejects.

Only Vacuum Metals gives you one-source service – Vacuum Metals Corporation, Division of Crucible Steel Company of America, provides a fully integrated service from melting and casting through mill rolling and nationwide distribution of finished mill products. And you can get not only small experimental lots, but now, thanks to our new 2500 lb. induction furnace – the nation's largest – you can also get large-scale continuous production quantities of vacuum-melted metals. If you have an application which these unique metals may improve, please write giving full details. *Vacuum Metals Corporation, Division of Crucible Steel Company of America, P. O. Box 977, Syracuse 1, New York.*

VMC®

VACUUM METALS CORPORATION

Division of Crucible Steel Company of America

Circle 524 on page 19

9 complete series of PERFECTION worm gear SPEED REDUCERS

available in ratios of 5 to 1 to 60 to 1

Perfection Worm Gear Speed Reducers by American Stock Gear are available with ratios ranging from 5 to 1 to 60 to 1 for input revolutions ranging from 300 per minute to 1800 per minute. Speed Reducers may be furnished with worm on top or bottom as desired. Integral worm and shaft is made of selected quality, case hardened alloy steel. Threads are precision ground and accurately mated with worm gear. Shafts are mounted in Timken anti-friction roller bearings. Heavy rigid cast iron housings . . . easily accessible oil filling level and drain plugs are provided for oil reservoir. Oil seals are of selected cirvis leather which assures maximum sealing effect. Available through your nearest American Stock Gear Distributor. If you don't know his name, write us.

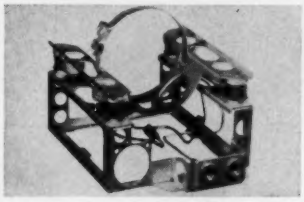
Write for 12 page Bulletin No. R-30 listing the complete Perfection Series together with tables and other important engineering data.

AMERICAN STOCK GEAR DIVISION

PERFECTION GEAR COMPANY • HARVEY, ILLINOIS, U.S.A.

New Parts

operating conditions. High percentage of inherent damping results in the reduction of resonant peaks and quick dissipation of



transient forces. Natural frequency is between 6 to 11 cps; amount of vibration isolation provided is approximately 90 per cent at 40 cps. Mounting system is designed in accordance with MIL-E-5272A, MIL-C-5541 and QQ-P-416. **Robinson Aviation Inc.,** Air Terminal, Teterboro, N. J.

Circle 754 on page 19

Silicon Diodes

have recovery time under 0.3 microsec

Fast-switching silicon diodes are available in four classes that provide recovery ranges from under 0.3 microsec with a minimum for-

ward of 5 ma at 1.5 v to 1 microsec with minimum forward of 100 ma at 1.5 v. All classes have types that operate at 200 v with low inverse leakages. **Transitron Electronic Corp.,** Melrose 76, Mass.

Circle 755 on page 19

Thermostat Metals

for instrumentation component use

Two thermostat metals are for use in instrumentation components such as electric fire detector clocks, meteorological devices, pyrometers, altimeters, temperature gages and demand meters. One of the metals possesses a useful deflection range of −100 to 700 F, with maximum sensitivity from 0 to 300 F. It has a high deflection rate, high torque and good strength properties up to 800 F. Electrical resistivity is high and corrosion resistance good. The

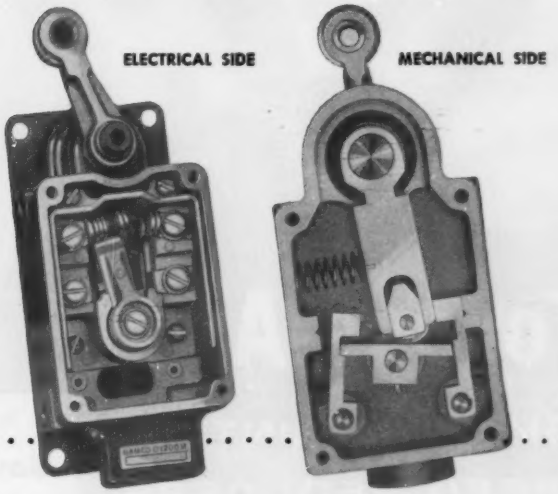
PROVED . . . by millions of contacts

NATIONAL ACME
SNAP-LOCK
TRADE MARK

As illustrated below, National Acme SNAP-LOCK Limit Switches employ a basically simple yet positive *snap-action* locking mechanism—with extremely few moving parts. Thus wear is reduced to a minimum and dependable trouble-free service, far beyond normal limits, is assured.

The double-throw contact lever, connected directly by shaft with the latch bar, carries self-wiping coin silver contact points to assure quick action make or break—reducing wear ever further.

Electrical and mechanical sides are separated by a wall within a sturdy die-cast housing which is fully insulated and is dust and oil resistant. Can also be furnished water- and oil-tight.



THE ORIGINAL SNAP-ACTION LOCKING SWITCH

SNAP-LOCK LIMIT SWITCHES. Made in single-pole and double-pole series, in four types: Standard, Short Travel, Neutral Position and Push Lever. With the exception of the Push Lever Switch, all are adaptable to special enclosures for hazardous location service and may be used with various styles of operating levers. For AC or DC service.

and now . . .

a new design concept for **CONTROL STATION SWITCHES**
the heavy-duty . . . oil, water, dust tight **GOLD-N-RING**
made by machine tool builders to machine tool specifications

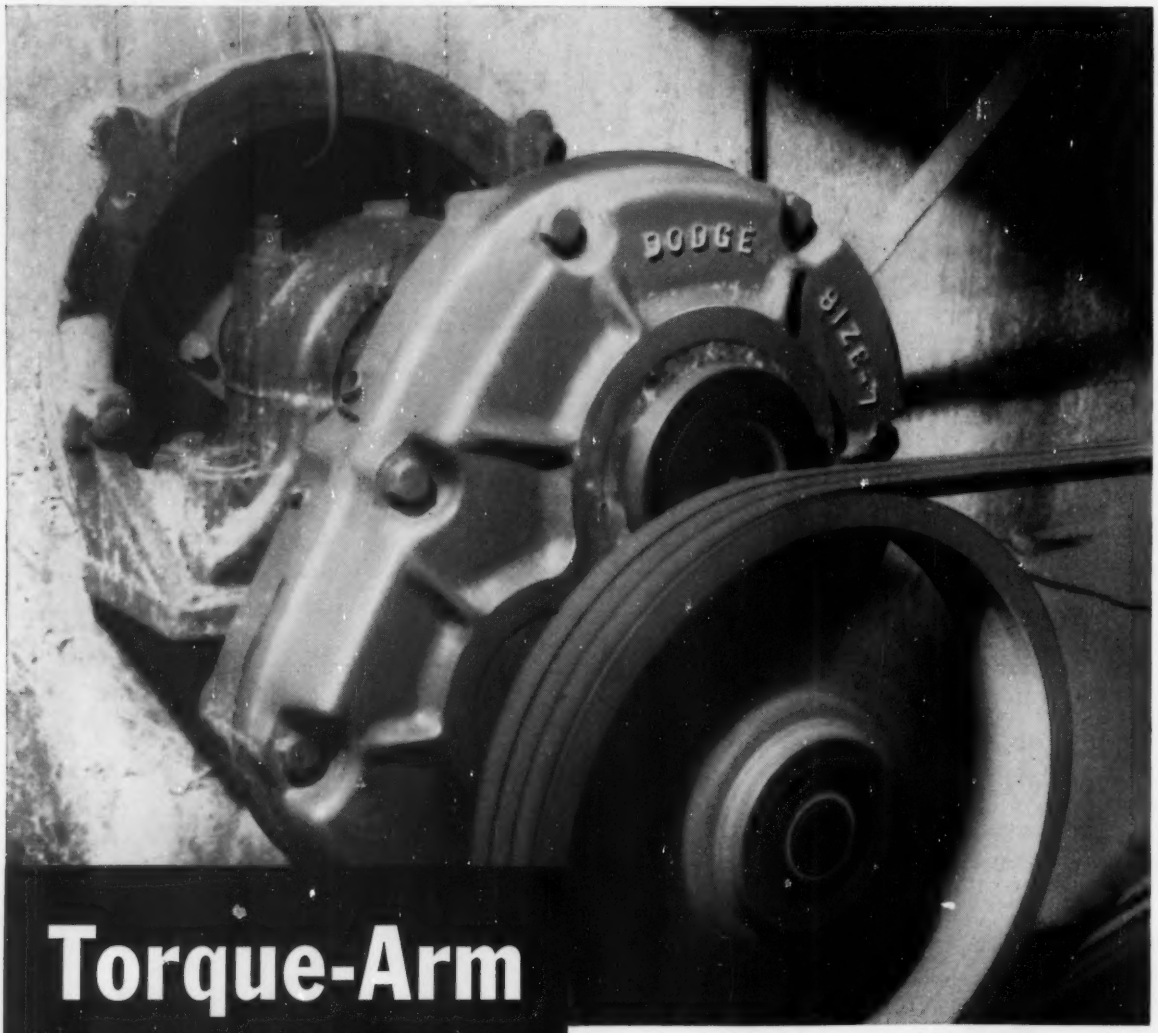
Heavy duty silver-alloy contact points provide maximum electrical capacity, long life.
Heavy duty terminal screws have 3/16" thread contact to prevent stripping during installation and permanently secure wires for continuous, trouble-free service.
Single or double-pole contact block assemblies—can be used interchangeably with several types of GOLD-N-RING push button and selector operator heads.
Rated for 600 volts—AC or DC. Meets all Joint Industry Committee and National Machine Tool Builder's Association requirements.
Protected against oil and water seepage in operator head by Sealtight oil-resistant rubber diaphragm.
Easily replaces existing switches.

ELECTRICAL MANUFACTURING DIVISION

the National Acme company

188 EAST 131st STREET, CLEVELAND 8, OHIO

Circle 526 on page 19



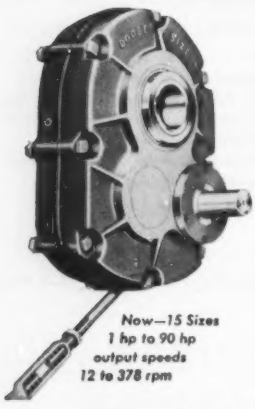
Torque-Arm

SHAFT-MOUNTED SPEED REDUCERS

Size 7 Torque-Arm Speed Reducer on agitator in paper mill

Save Up to 1/3 in Installation

—Deliver 97% Efficiency!



Now—15 Sizes
1 hp to 90 hp
output speeds
12 to 378 rpm

Easy to install! Mounted directly on the driven shaft. Locked at both ends. Dodge Torque-Arm Speed Reducer requires no foundation, no flexible coupling, no sliding base, and there's no lining-up problem. Amazing economy is matched by efficiency in operation—up to 97%.

Unit is driven through V-belt drive. Stock Taper-Lock Sheaves prescribed for each job permit speed ratios required. Tri-Matic Overload Release and backstop available, if desired. Dodge Torque-Arm is America's most complete line of shaft-mounted Speed Reducers. Ask your Dodge Distributor—or write us.

•

DODGE MANUFACTURING CORPORATION
3300 Union Street, Mishawaka, Indiana

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new methods. Look for his name under "Power Transmission Machinery" in the yellow pages of your phone book—or write us.

DODGE
of Mishawaka, Ind.

Circle 527 on page 19

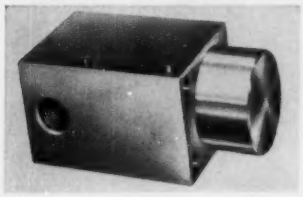
other metal has a wide range of linear deflections between −50 and 700 F. Maximum sensitivity is 200 to 600 F. It combines high deflection rate with high torque. Metals are produced in minimum thicknesses of 0.001-in. and minimum widths of 0.093-in., in coils or lengths cut to order. **American Silver Co.**, 36-07 Prince St., Flushing 54, N. Y.

Circle 756 on page 19

Air Cylinders

in compact sizes for all strokes

Toolmor air cylinders give a full line pressure power thrust with heavy hardened steel piston for long life. Square and parallel sides provide easy tooling installation and arrangement, permitting



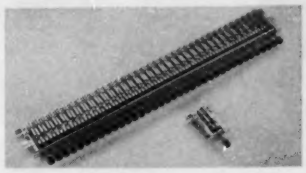
mounting with 1/16-in. parallel of work. Universal mounting permits either horizontal or vertical thrust use. Units are available with standard, ball, swivel, threaded or tool - blank piston ends which provide selection of tools in strokes from ⅜-in. Design provides compact sizes in all strokes. **Burklyn Co.**, 3429 Glendale Blvd., Los Angeles 39, Calif.

Circle 757 on page 19

Switch

in any multiple of stations from 1 to 37

Modified Multi-Switch is manufactured in any multiple of stations from 1 to 37. Functions available include: interlock, nonlocking, all lock, interlock and nonlock combination, and all lock and nonlock combination. Design incorporates choice of mounting centers, center-to-center distance between buttons of ⅝-in., plungers designed to accept standard push-on buttons, and stock switches mounted on a separate plate. Up to four stacks can be operated by each button to provide many circuit possibilities. Design permits ganging of two or



more rows of switches with interlock action between all buttons. Switches have good shock resistance and are available with illuminated or nonilluminated pushbuttons. **Switchcraft Inc.**, 1328 N. Halsted St., Chicago 22, Ill.

Circle 758 on page 19

Miniature Delay Relay

for missiles and jet aircraft

Miniature thermal delay relay (left) is a vibration-resistant unit specifically designed for applications in missiles and jet aircraft. Design features include: virtual

elimination of contact chatter up to 1500 cps at 10 *g;* no resonance to 500 cps; good ambient compensation between −65 and 85 C with operation at higher temperatures when necessary; contacts rated for 1 amp at 27.5 v dc or 3 amp at 115 v ac; and rigid construction for exceptionally high contact pressure. Relay is sealed in a metal shield and permanently calibrated before shipment. Seated height is 2 in., diameter, ¾-in., and weight, 1 oz max. **Thomas A. Edison Industries,** Instrument Div., 51 Lakeside Ave., West Orange, N. J.

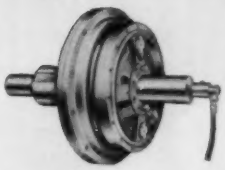
Circle 759 on page 19

Styrene Molding Compound

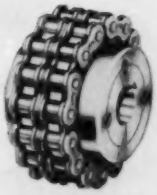
is medium-impact type

Lustrex LHA Natural, a medium-impact styrene molding material with improved transparency, is for applications requiring more impact

DODGE PRODUCTS you should know



AIR-GRIP CLUTCHES



CHAIN COUPLINGS

SEALED-LIFE V-BELTS

DODGE BULLETINS YOU SHOULD HAVE

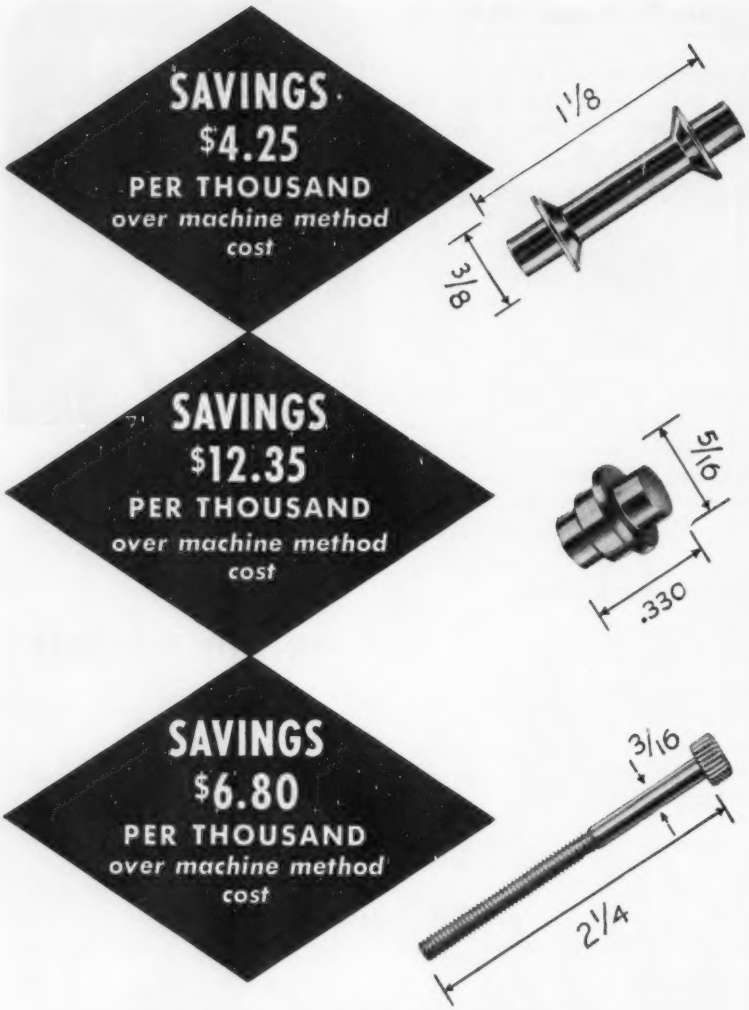
- ✓ Air-Grip Clutches. Technical data, sizes and selection tables. Bulletin A634
- ✓ Chain Couplings, Taper-Lock Sprockets and Dodge Roller Chains. Technical data and selection methods. Bulletin A644
- ✓ Sealed-Life V-Belts. Construction details and complete data on sizes, pitch lengths and outside lengths. Bulletin A606

Write for your copies.

DODGE MANUFACTURING CORPORATION
3300 Union Street • Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

Circle 528 on page 19



COLD-HEADING

SAVES YOU MONEY ON JOB-DESIGNED SMALL PARTS AND FASTENERS

Cold-Heading is the most versatile, most economical method for producing your fasteners and small parts. These case histories are typical of thousands of money saving jobs we've done for our customers. May we quote on your requirements? Write today for the Hassall Catalog.

John Hassall, Inc., P.O. Box 2197, Westbury, Long Island, N.Y.

Hassall

SINCE 1850

NAILS, RIVETS, SCREWS
AND OTHER COLD-HEADED
FASTENERS AND SPECIALTIES

Hassall

Circle 529 on page 19

New Parts

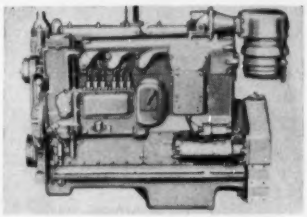
strength than general-purpose styrenes provide, but requiring greater clarity than high-impact styrenes afford. Many potential applications are in the packaging field. **Monsanto Chemical Co.**, Plastics Div., Springfield, Mass.

Circle 760 on page 19

Engines

develop up to 137 hp and are light and compact

D 318 and D 315 Series G engines are designed for applications where space and weight are important factors. Reductions in size and weight were made possible by using a timing gear and housing which require half as much length as previously, placing



air cleaner in a new position to give shorter, lower engine profile, and replacing gasoline starting engine with a 24-v direct electric starting system. D 318 Series G engine (shown) has over-all length of about 56 in. It develops 137 hp at 2000 rpm; turbocharging increases this rating to 175 hp. D 315 Series G engine develops 91.5 hp naturally aspirated; 115 hp can be obtained by turbocharging. Series G engines are suitable for powering portable welders, crushers, pumps, mills and other machines. **Caterpillar Tractor Co.**, Peoria, Ill.

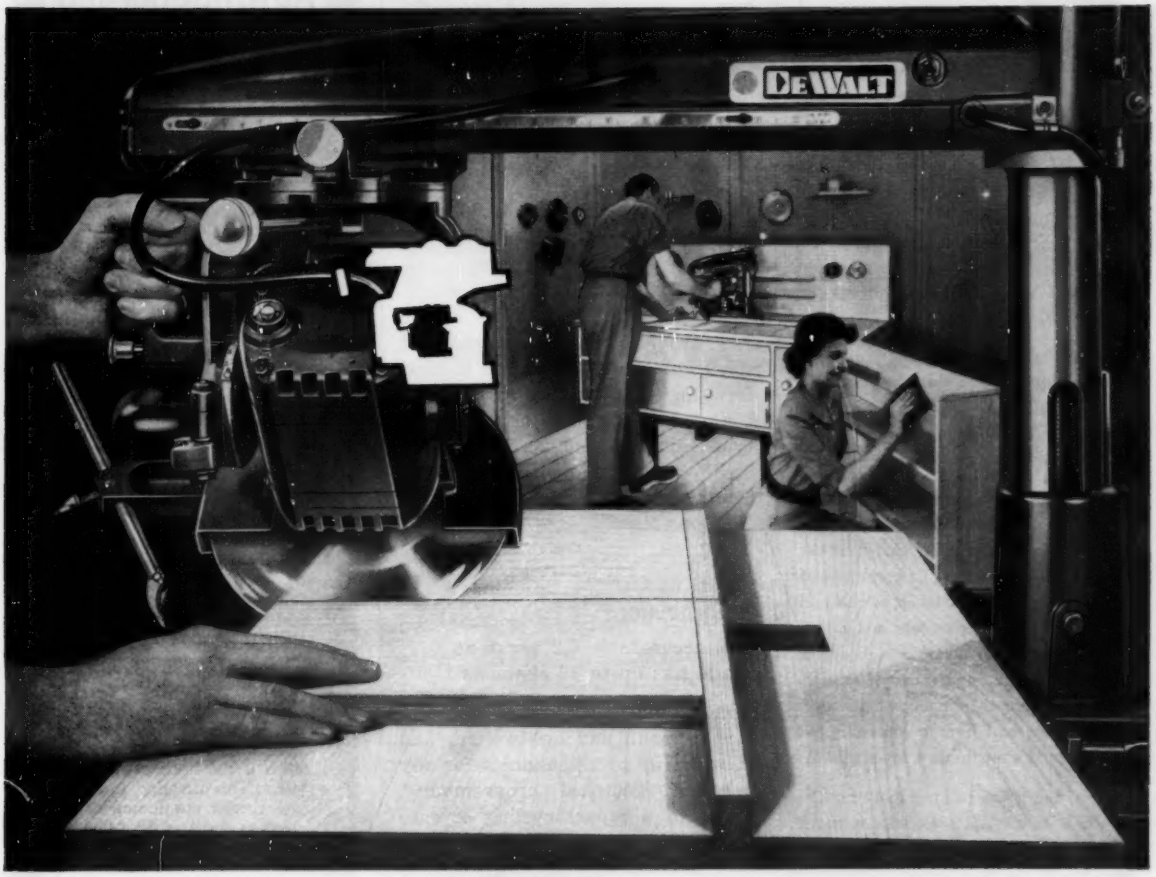
Circle 761 on page 19

Solenoid

delivers 20-lb thrust at 100 per cent voltage

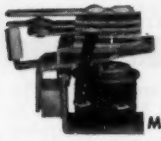
Model K solenoid is available for intermittent duty, both in push and pull types. It withstands excessive impact shock and delivers 20-lb thrust at 100 per cent voltage. Design employs a solid cylindrical slotted plunger to eliminate rivet failure found in conventional solenoids. Heavy-duty, porous

Potter & Brumfield *engineering is in this picture*

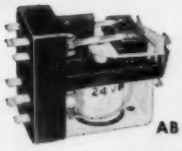


Which P&B relay would you specify for

THIS HIGH STARTING TORQUE MOTOR?


MP SERIES

MS SERIES


AB SERIES

Radial Saws by DeWalt, Inc. are used in thousands of home workshops, in lumber yards, carpenter shops and industry. The electric motors that operate these saws are a heavy duty, single phase, AC, modern capacitor, voltage relay type. They have a *high starting torque* in order to quickly achieve operating speed, even when heavy line loads give lower voltage than normal. To avoid arcing and burning during initial current surge, DeWalt needed a positive, fast acting relay that would remain in contact until operating speed was reached.

Their choice? P&B MP series relays! These sturdy relays not only save arcing and burning during initial current surge, but are compact, rugged and dependable. Their versatility permits use with any capacitor type motor up to 2 horsepower. They can be furnished with an alnico magnet if whole snap action is needed.

This ready solution to DeWalt's relay problem is an example of how P&B relay engineering is daily adapting existing relay types to specific needs. P&B's unique 25 years of relay engineering experience provides an immense reservoir of skill, information and technical ability that can help solve your relay problems faster and more efficiently.

ENGINEERING DATA

SERIES: MP. Small general purpose power relay.

CONTACTS: ⅜" fine silver rated 25 amp., 115 V. AC non-inductive load, or 2 HP, 115 V. AC.

CONTACT ARRANGEMENTS: SPST NO, SPST NC, SPDT.

VOLTAGE RANGE: DC: Up to 220 V. AC: Up to 230 V.

COIL RESISTANCE: 15,000 ohm maximum.

TEMPERATURE RANGE: DC: —55° C. to +85°C. AC:—55°C. to +55°C.

TERMINALS: Standard pierced solder lug holes will take No. 10 hook-up wire.

ENCLOSURES: Dust cover, 2-59/64" L. x 2¼" W. x 2-3/32" H. Hermetically sealed cover dimensions same as above.

DIMENSIONS: Maximum 2¼" L. x 1¼" W. x 1⅞" H.

This relay will normally deliver a minimum of 300,000 operations before wear will warrant readjustment.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC, ELECTRICAL, AND REFRIGERATOR DISTRIBUTORS

See our catalog in Sweet's Product Design File

Potter & Brumfield, inc. PRINCETON, INDIANA

Subsidiary of AMERICAN MACHINE & FOUNDRY COMPANY • Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

A Job For A TWO-HEADED MONSTER

Wm. H. Knox

PLANT SUPERINTENDENT, THE CINCINNATI GEAR CO.

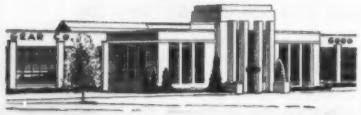
Some of the men here look on me, I'm sure, as a modern Simon Legree with a nine-foot bullwhip — which isn't really a true picture at all. In fact, I think I'm pretty easy to get along with.

But there are times when I think this job of plant superintendent calls for someone with the attributes and physical characteristics of a two-headed monster. To keep track of a couple hundred different men, working on almost as many different jobs and different machines, all involving a high degree of skill and exacting accuracy, requires something more than mere attentiveness to duty. It means I have to constantly put forth an *extra* effort to do a top-notch job.

Not that I'm trying to brag about myself; my job is tough and sometimes it seems thankless, but it has its compensations. And one of the most important of these compensations is the satisfaction of knowing that my efforts are not being wasted. Because *everyone else* here is "putting out" to do *his* part too, with the result that we have a top-notch Company turning out a top-notch product — something that our customers have come to expect from us as a matter of course.

THE CINCINNATI GEAR CO.
CINCINNATI 27, OHIO
Fifty Years of "Gears—Good Gears Only"

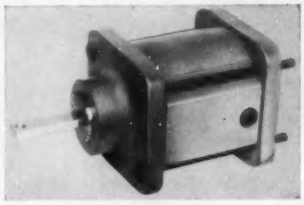
CINTI®



Circle 531 on page 19

New Parts

bronze bearings assure complete alignment of both plunger and plunger extension. Square wire in the coil improves heat dissipation



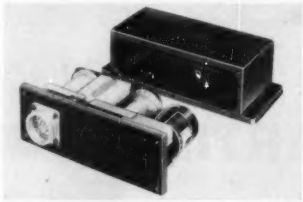
and provides greater mechanical strength. Glass insulation is used for high-temperature operation. Unit operates on 115 or 220-v, 60-cycle, single-phase ac. It is 5¼ × 3¾ × 3⅝ in. in size and weighs 6 lb 11 oz. **Black & Webster Inc.,** Newton, Mass.

Circle 762 on page 19

Programmer

is accurate to 0.2 per cent and has up to 13 channels

MPR-13 multiple channel programmer is small and lightweight, and provides up to 13 channels for any type of electrical programming, either of a repeat cycling or ran-



dom nature. Accuracy is of the order of one part in approximately 50,000. Programmer is housed in a magnesium casting, providing high strength and resistance to shock and vibration. Unit weighs 3 lb 10 oz and measures 2 × 3 × 6 in. **Photographic Products Inc.,** 1000 N. Olive St., Anaheim, Calif.

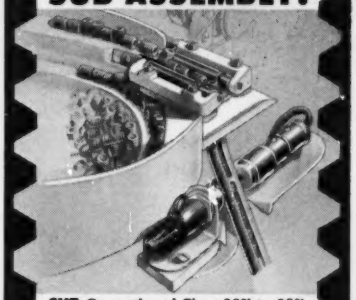
Circle 763 on page 19

Valve Positioner

eliminates inherent transmission lag

Model E electropneumatic positioner is available as an integral component of Series LB control valves with single-seated, split-valve bodies. Positioner provides valve positioning directly proportional to

NOW, hopper-fed headless set screws AUTOMATE SUB ASSEMBLY!



CUT Operational Time 80% to 90%
CUT Floor Area
CUT Floor Waste from 30% to 0
CUT Worker Fatigue

The new Setko System can be used for almost any headless set screw application in sub or final assembly. All type points and most popular styles of set screws can be hopper fed.

The illustration above shows the Syntron vibratory hopper and exclusive Setko orienting device which is the heart of this new system. This orienting device assures correct positioning of set screws as small as #2 (.086" x ⅛"). Other Setko innovations include photo-electric cell control of feed flow, air power, and micro-switch actuation of the driver.

HEXAGON AND FLUTED SOCKET SET SCREWS | SLOTTED SET SCREWS | SLABBED SET SCREWS

Two Models are available. The Vertical Feed Model adapts to drill presses, vertical tapping machines, etc. The Universal Model for horizontal feeding can be used as a separate unit, or with rotary indexing work tables.

Free Demonstration in Your Plant or Ours... Arrange to visit the Setko plant, or ask for the loan of the new 12 minute 16-mm color movie that gives a "demonstration" in your plant or office. Ask for a copy of Catalog 21, which describes the new Setko System, plus the complete line of Setko standard and special types of set screws.

Pat. No 2,638,945
Other Patents Pending

Set Screw & Mfg. Co.
1907
28 Main Street, Bartlett, Illinois

Circle 532 on page 19

NEW . . . Armstrong resilient clutch facings withstand high pressures, high temperatures

Armstrong now offers a group of resilient friction materials designed to operate under the higher closing pressures, higher temperatures, and faster speeds found in many of today's transmissions.

The compositions are made by an entirely new patented process that combines organic and inorganic fibers with synthetic saturants. They are now operating smoothly in transmissions where closing pressures are up to 400 psi. In some experimental transmissions, the new clutch facings are being used at pressures as high as 2,000 psi.

These friction materials have high torque capacity and show virtually no change in coefficient of friction during their long service life. They are designed to run at ambient temperatures in the 250°-315° F. range, and they are not affected by the much higher flash temperatures often encountered under severe engagement.

Send for detailed technical data — including performance curves. It's contained in our new friction materials booklet. Write Armstrong Cork Company, 7203 Dean Street, Lancaster, Penna.

Armstrong RESILIENT FRICTION MATERIALS

. . . used wherever performance counts

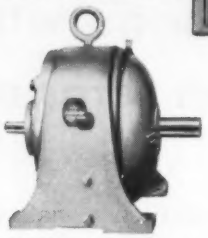
Circle 533 on page 19

Here's your

"Buyer's Guide"

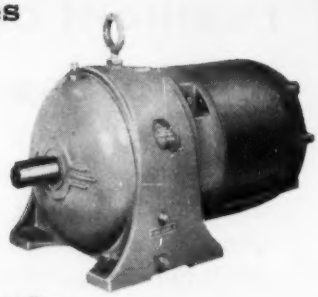
to the world's finest enclosed gear drives

FOOTE BROS. standard enclosed gear drives



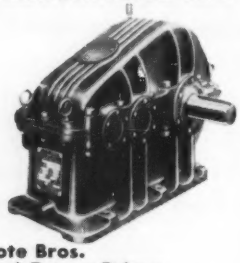
Foote Bros.
Line-O-Power Drives

Available in straight line and right angle units, Line-O-Power drives feature Duti-Rated gearing. Foot or flange mounted, single, double, triple or quadruple reduction. Cast housing assures permanent alignment. Ratios to 2726 to 1. CATALOG LP NO. 3.



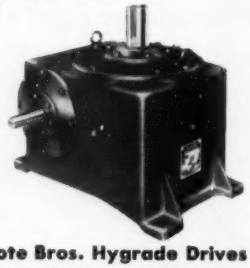
Foote Bros.—
Louis Allis Gearmotors

Famous, dependable Louis Allis motors and Foote Bros. quality Duti-Rated Gearheads form a perfect combination for power. Capacities range to 150 h.p., output speeds to 780 r.p.m. Available foot or flange mounted, horizontal or vertical models. CATALOG MRA.



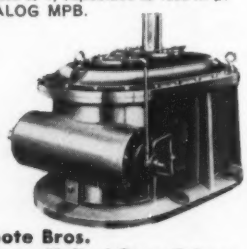
Foote Bros.
Maxi-Power Drives

Compact, rugged helical geared units provide years of trouble-free, dependable performance. Designed for severest service. Available in ratios up to 360 to 1, capacities to 1550 h. p. CATALOG MPB.



Foote Bros. Hygrade Drives

Here's high efficiency and load carrying capacity for heavy duty. Precision worm geared Hygrade drives are available in ratios up to 4108 to 1, capacities to 260 h.p. CATALOG HGB.



Foote Bros.
Worm-Helical Gear Drives

Designed for heavy-duty stirring, mixing or agitating applications, Foote Bros. Worm-Helical Drives are available with horizontal input shaft, vertical up or down or both output shaft. Ratios range to 285 to 1, capacity to 128 h. p. CATALOG WHB.

This trademark stands for the finest industrial gearing made

T.M. REG.
U.S. PAT. OFF.

For complete details on any one, or all, of the drives shown here, write for informative literature . . . note specific catalogs designated. There's a size and type Foote Bros. drive to meet every need.

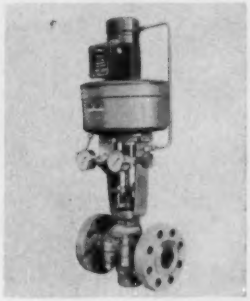
FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION

4567 S. Western Blvd. Chicago 9, Ill.

dc signals received from electronic instruments. Electropneumatic transducer is not required, and 100



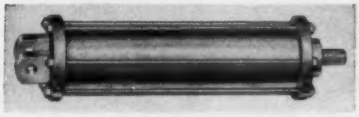
psi air supply can be used. Unit eliminates the inherent transmission lag of all-pneumatic systems. **Conoflow Corp.**, 2100 Arch St., Philadelphia 3, Pa.

Circle 764 on page 19

Air Cylinder

for heavy-duty service

This air cylinder has an alloy-steel capsule-type gland designed especially for heavy-duty service, long rod guide and independently adjustable V-rod packaging. Bronze rodwiper ring prevents foreign material from entering cylinder. Cylin-



der heads are cut from steel plate. Heads, steel clevises and steel pistons are cadmium plated. Static seals are standard AN O-rings. Operating pressure is 150 psi air and 500 psi hydraulic service. Cylinder is available in strokes to 18 ft, from 3 through 8 in. bore with a variety of piston rod sizes. **Densmore Engineering Co. Inc.**, 235 E. Greenleaf St., Compton, Calif.

Circle 765 on page 19

Titanium Powder

has high purity and low oxygen content

UniFide titanium powder can be formed by powder metallurgy into corrosion and erosion-resistant parts such as gears, bearings, cams, wheels and dies. Powder is produced directly as a loose ag-

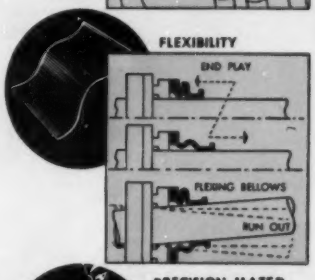
(*Continued on Page* 230)

JOHN CRANE

Shaft Seal Design With A Purpose!

POSITIVE DRIVE

This gives long seal life. Drive is transmitted through the driving band and washer driving notch which absorb all breakout and running torque. Damaging stresses on the bellows or flexible sealing member are eliminated. Slippage is also eliminated, thus protecting shaft or sleeve against galling.



FLEXIBILITY

Axial and radial misalignment problems are eliminated. Self-adjusting bellows or sealing head automatically compensates for shaft end play or run out. Minimum spring pressure is required for axial shaft movement and uniform spring pressure is maintained during radial shaft movement.

PRECISION MANUFACTURE

Leakproof performance is assured. Washer and seat surfaces are precision lapped to a perfect mate under a patented "John Crane" process.

A SEAL FOR EVERY SERVICE

All "John Crane" Seals are constructed to the particular service requirements . . . from hot or cold water to the most destructive acids, corrosives and gases . . . temperatures up to 1000°F. . . . pressures to 1200 psi. They can be furnished in types and sizes to meet practically any mechanical or dimensional condition.

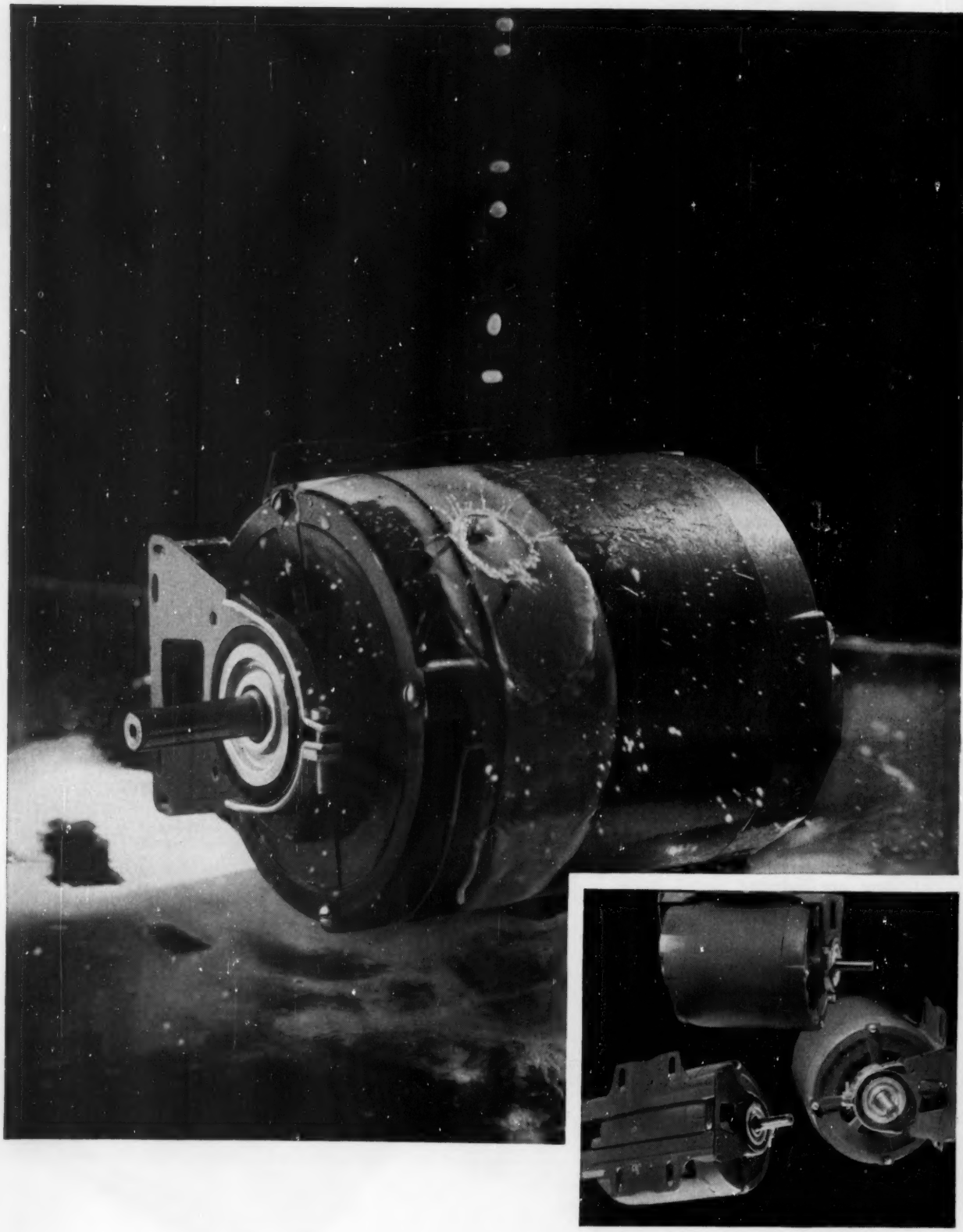
Request Bulletin S-204-2. Containing full information on "John Crane" engineered shaft seals.

GET COMPLETE DETAILS

Crane Packing Co., 6425 Oakton Street, Morton Grove, Ill. (Chicago Suburb)

In Canada: **Crane Packing Co., Ltd., Hamilton, Ont.**

CRANE PACKING COMPANY



Fact 1 . . . no "swiss-cheese" vent holes in the solid frame to restrict mounting angles or allow liquids or dirt to damage windings.

Westinghouse Offers the Only True All-Position Mounting Motor

. . . one important FACT about the new Westinghouse 48-frame fhp motor

A solid, protective frame plus 22% more oil capacity helps make the new Westinghouse 48 frame the only true all-position mounting motor.

By using a straight-through ventilation system—which actually boosts cooling ability—the need for holes in the frame is eliminated. The rigid protection of the solid cover keeps out harmful liquids, dust and dirt, no matter what the mounting angle. Gone, too, are the bothersome whistle noises of other motor designs.

A positive oil-return lubrication system protects the new Westinghouse motor regardless of mounting position . . . your assurance of smooth performance for longer periods, even at peak loads.

Don't expect all these benefits in any other motor.

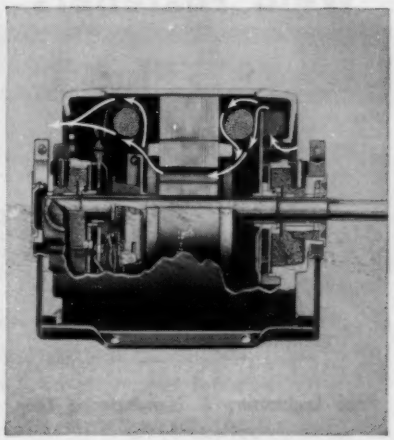
The Man With The Facts, your Westinghouse sales engineer, has all the information about this new fhp motor line. Contact him today. Or write for DB-2801. It contains complete technical data. Westinghouse Electric Corporation, Small Motor Division, Lima, Ohio.

J-03020

YOU CAN BE SURE...IF IT'S Westinghouse

Fact 2 . . . up to 40% less space needed to stock some sizes. And the motor takes less room in your product, too.

Fact 3 . . . weight savings up to 50%. Conserves mounting and housing space . . . lowers material and shipping costs.



Fact 4 . . . straight-through ventilation assures cooler operation for longer running periods, even at peak loads.

Circle 536 on page 19

•Engineered projections. No burn-outs on thin sheets. Simple electrodes. No pilots required.
• Self locating. Shank protects threads from weld splatter. No retapping.
• Round shape. No indexing in assembly. Compactness permits use on narrow flanges.

PEM
Weld Fasteners

STEEL
or
STAINLESS
(non-corrosive—non-magnetic)

Speed assembly—cut costs. Write for literature and samples for trial.

Penn Engineering & Manufacturing Corp.
Doylestown, Pa.

PEM

New Parts

(*Continued from Page 227*)

glomerate, then crushed and sized. Of high purity with a low oxygen content, it is also stable in air. It can be shipped dry and handled with ordinary precautions. **United International Research Inc.**, 38-15 30th St., Long Island City 1, N. Y.

Circle 766 on page 19

Linear Servo Accelerometer

with range of 0 to 25 cps has high output levels

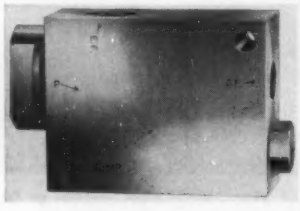
Model 4112 linear servo accelerometer, incorporating a high-gain electro-mechanical amplifier in closed-loop operation, is designed for precise measurement or control of linear acceleration over a frequency range from 0 to 25 cps. It

is especially suited to aircraft and missile applications where rugged construction and high accuracy are needed. Internal servo system provides resolution of better than 0.001 per cent and linearity within 0.1 per cent of full range. High output levels are obtainable, eliminating need for further amplification. Standard input ranges from ± 0.1 to ± 20 *g* are available, each with high overload capacity. **Donner Scientific Co.**, Concord, Calif.

Circle 767 on page 19

Flow Divider

divides flow in any proportion



Flow divider can be adjusted with screwdriver to control flow over a range from 10 to 95 per cent as

When to specify

VULCAN ELECTRIC FINNED STRIP HEATERS

1. When application is for: Blower type electric unit heaters, duct heating, unit convection heating, as oven or space heaters in dryers, pump rooms, switch towers, etc.

2. When specifications call for: Steel sheath for sheath temperatures to 750°F; Chromalloy sheath for sheath temperatures to 1200°F; length — 10½″ to 42½″ (or higher); wattage — 500 to 3250 (or higher); voltage — 115 or 230; rugged non-oxidizing terminal posts.

3. When you have "hot" problems: Vulcan Engineers are ready to provide special heating units — engineered to *your* needs.

NEW FINNED TUBULAR HEATERS

Vulcan's new Finned Tubular Heaters provide six times as much radiating surface as standard tubular heaters. Fin is spirally edge wound from continuous strip of steel, then silver brazed to surface of sheath. Heaters can be formed at factory into one or a series of hairpin bends.

Write for free catalog.

VULCAN
ELECTRIC COMPANY
DANVERS 6, MASS.

Cartridge • Strip • Tubular • Immersion Electric Heaters • Soldering and Branding Irons Solder and Glue Pots

Circle 537 on page 19

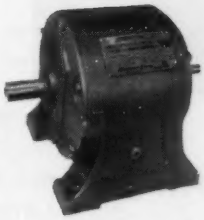
Circle 538 on page 19

WESTERN GEAR-O-GRAM

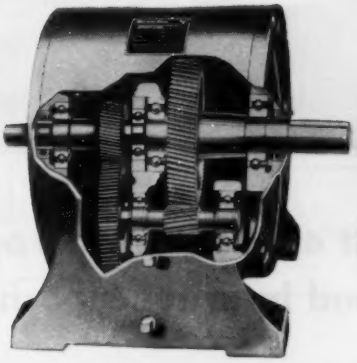
NEW PRODUCT NEWS

INVESTIGATE ADVANTAGES NEW WESTERN GEAR STRAIT-LINE SPEED REDUCERS STOP COMPACT IN-LINE DRIVES SIGNIFICANT ADDITION TO WESTERN GEAR LINE OF QUALITY POWER TRANSMISSION PRODUCTS STOP SEND FOR FULL INFORMATION STOP ASK FOR BULLETIN 5616=

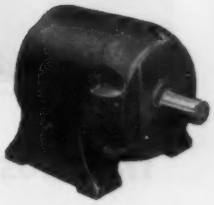
WESTERN GEAR STRAIT LINE SPEED REDUCERS



Double Reduction Type RD

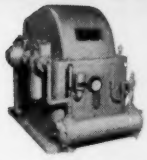


Cutaway View Double Reduction Type RD



Triple Reduction Type RT

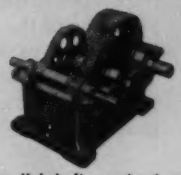
. . . And here are other members of the ***WESTERN GEAR*** *quality line of mechanical power transmission equipment. They're tops in dependability, backed by 69 years of experience!*



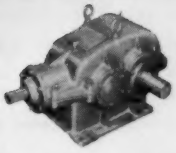
High speed unit

Integral gearmotor

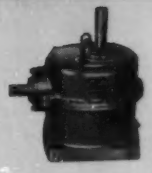
All motor gearmotor



Parallel shaft speed reducer



Right angle speed reducer



Vertical speed reducer

"The difference is reliability" • Since 1888

5751

WESTERN GEAR Corporation

ENGINEERS AND MANUFACTURERS

PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.) SEATTLE AND HOUSTON — REPRESENTATIVES IN PRINCIPAL CITIES

Circle 539 on page 19

WESTERN GEAR CORPORATION
P.O. Box 182, Lynwood, California

Please send me Bulletin No. 5616

NAME_____

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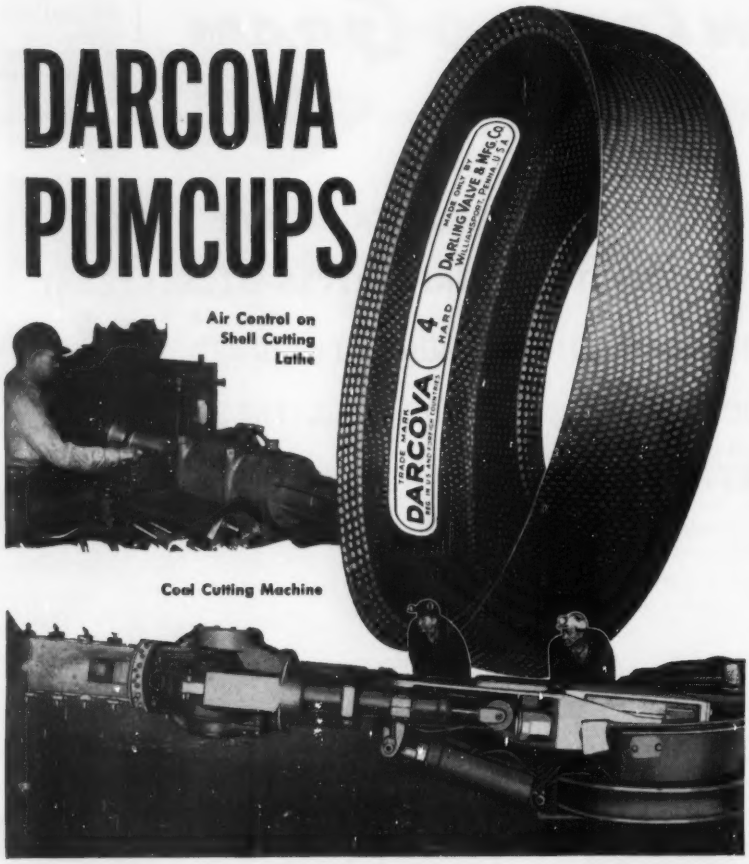
COMPANY_____

STREET ADDRESS_____

CITY_____ STATE_____

DARCOVA PUMCUPS



The most efficient piston packing for air and hydraulic mechanisms

MORE and more plants are adopting Darcova Pumcups as the standard packing for air and hydraulic cylinders in machine tools, presses, hoists, lifts, rams, pusher mechanisms, controls, regulator valves, spraying equipment and various types of machinery . . . using air, oil, water and other fluids.

There are two basic reasons why Darcova Pumcups have proved to be more efficient: (1) Texture engineered Pumcups outlast most other piston packing at least 3 to 1. (2) Pumcups operate at full efficiency *throughout* their entire life span.

Fewer shutdowns, lower operating costs and longer cylinder life . . . are some of the advantages of Darcova Pumcups. Send for all the facts. Write for Bulletin No. 4502 on Pumcups for air and hydraulic mechanisms.

DARCOVA
THE ORIGINAL COMPOSITION CUP

DARLING VALVE & MANUFACTURING CO.
Williamsport 30, Pa.

PUMCUPS

New Parts

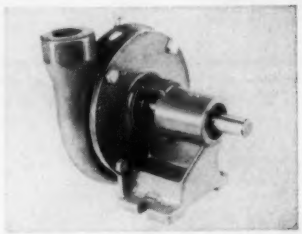
circuit requires. Built-in relief valve passes oil back to the sump when peak pressure setting of the secondary flow is reached. When pressure of the primary operation builds up, flow to the secondary operation decreases. Divider permits two simultaneous operations from one pump. It operates on low circulation pressure from pump and divides flow in any proportion. Unaffected by temperature, it has compact design which makes it easy to install and service. **New Products Corp.**, 3636 Oakton St., Skokie, Ill.

Circle 768 on page 19

Centrifugal Pump

has heavy-duty construction

Pryco general-purpose centrifugal pump provides increased life and minimum maintenance since there are no grease fittings or packing glands to service after installation. Impeller is securely screwed on



threaded shaft and cannot work loose or get out of adjustment. Increased head and volume are possible because heavy-duty construction permits higher speeds. Other design features include double ball bearings, mechanical shaft seals and lifetime lubrication. **E. L. Price Pump Co.**, P. O. Box 357, Sonoma, Calif.

Circle 769 on page 19

Remote Positioner

has rapid response and high accuracy

Electrolink remote positioner operates on standard 60-cycle power and combines rapid response with high accuracy. Unit is compact, weighs 16 lb, and is adjustable to varying requirements. It reaches maximum speed in 1/50 second and is accurate within 0.5 deg. Three

Control Problems?... Consult CONTROL EXPERTS

Control for Every Industry...Designed by Allis-Chalmers

THE world's largest line of major industrial equipment is produced by Allis-Chalmers. In supplying equipment to all industries, Allis-Chalmers has been called upon to provide every conceivable type of control ... STANDARD, MODIFIED and SPECIAL DESIGN ... in thousands of applications. This experience can help solve any or all of your control problems ... when you specify *Allis-Chalmers Control.*

For Expert Help With Your Control Problems... call your Allis-Chalmers representative. His recommendations are backed by Allis-Chalmers specialized engineering staffs ... by complete research and testing facilities.

For further information call your nearby A-C office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

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- Metal Fabricating
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- Chemicals
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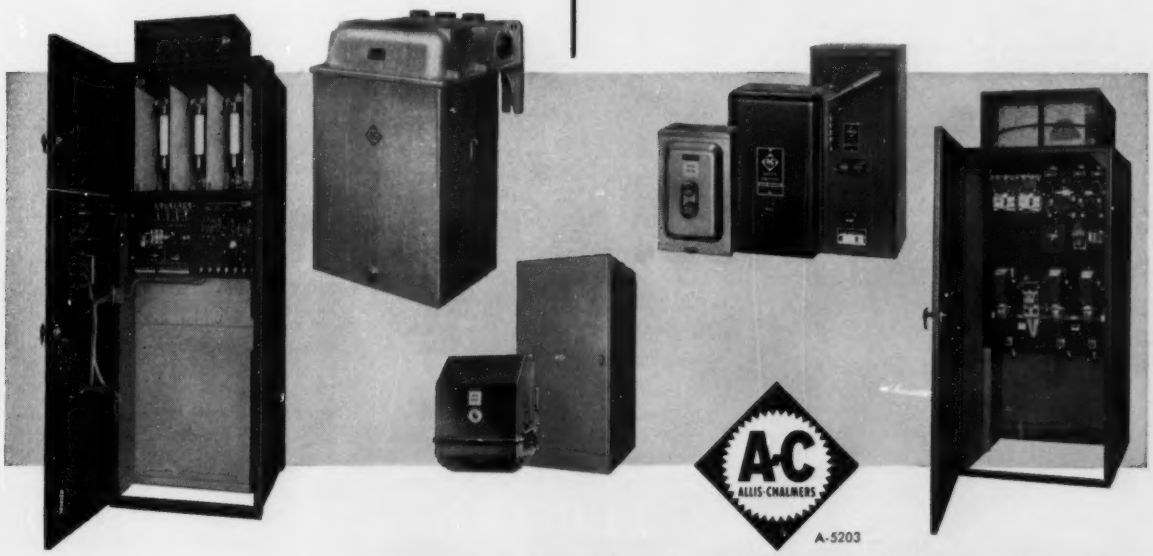
- Automotive



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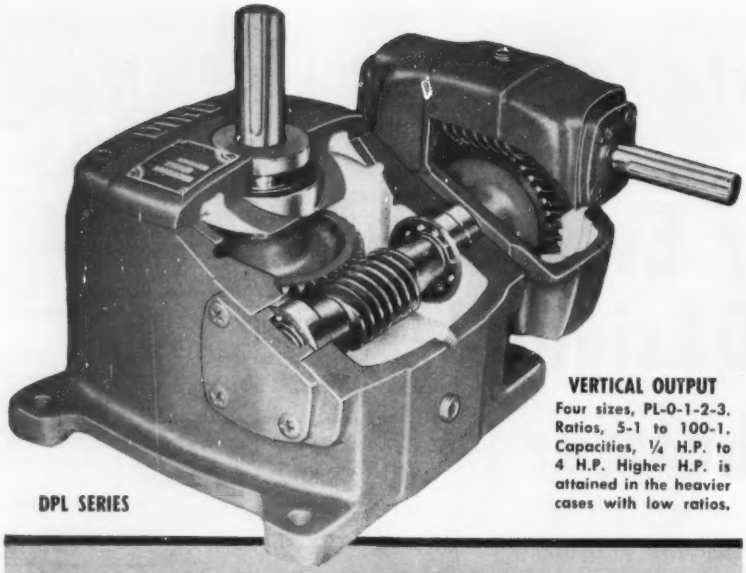
ALLIS-CHALMERS

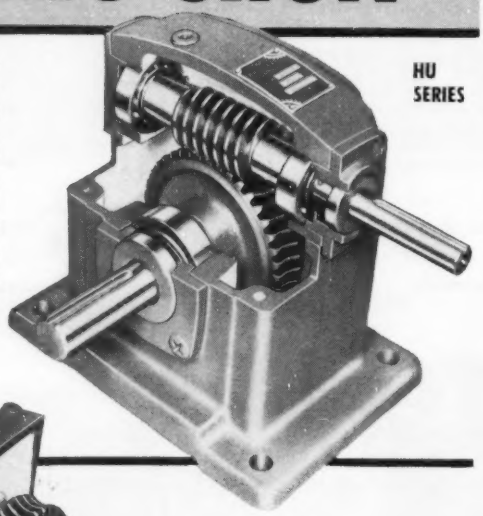


DPL SERIES

VERTICAL OUTPUT
Four sizes, PL-0-1-2-3. Ratios, 5-1 to 100-1. Capacities, ¼ H.P. to 4 H.P. Higher H.P. is attained in the heavier cases with low ratios.

SPEED OHIO REDUCERS
"off the shelf"

• Ohio Stock Speed Reducers have been enthusiastically accepted among nationally known manufacturers for their sound engineering, long economical operation, and found to give the greatest satisfaction under a wide range of Industrial applications.



HU SERIES

WORM ON TOP
Single reducers. Input shaft is above and output shaft below. Includes 5 sizes, HU-0-1-2-3-4. Ratios, 5-1 to 100-1.

DOUBLE SPEED
For heavy duty service, Nos. DOT and D-1-3-4-5-6. Ratios to 3200 to 1. Torque capacities, 25 to 12000 in. lbs.

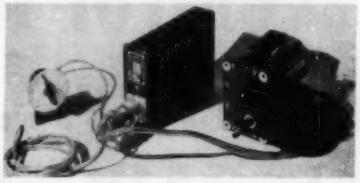
D SERIES

THE OHIO GEAR CO.
1338 E. 179 ST. • CLEVELAND 10, OHIO

ESTABLISHED 1915
OHIO GEARS

New Parts

basic components are: Data link, which converts manually-positioned input into error voltage; amplifier, which processes signals from the data link and a velocity signal from the servo drive; and the servo



drive, which incorporates an integral generator and provides power output to the load. Magnetic-powder clutch isolates the inertia of rotating servo components from driven load. Torque-to-inertia ratio is high, increasing accuracy and response. **Lear Inc.,** Dept. 80, Grand Rapids 2, Mich.

Circle 770 on page 19

Self-Adhesive Film

is tarnishproof and resists abrasion

Self-adhesive Mylar polyester film has high-tack adhesive on one side that adheres permanently to any clean, smooth surface. It can be used to trim a wide variety of products, and for fabricating name plates, special decorations, emblems and protective kick pads. Material is tarnishproof, resists abrasion, moisture, organic solvents, most acids and alkalis, and is flexible for application around product contours. It is available in metallic gold, chrome and colors in a variety of embossed designs. **Fasson Products,** Industrial Products Div., Painesville, O.

Circle 771 on page 19

Torque Motors

for aircraft and missile servosystems

Torque motors for aircraft and missile servosystems have a highly efficient magnetic circuit and operate with high natural frequencies and low phase lag. Brazed and welded together, they withstand adverse temperature and vibration conditions without zero shift. The motors meet military specifications and are available in

Note—Commercial and Military Packaging Engineers:

LINK-LOCK

...is the rugged answer to your exacting container closure problems

LINK-LOCK plays an important role in the design of this container

Simmons' LINK-LOCK provides pressure-tight, impact-resistant closure, plus quick closing and opening, on this reinforced fibrous plastic product made by the new automatic pre-form process developed by Pressurform Container Corp. The two-section container will be used by the Light Military Electronic Equipment Dept. of General Electric Company for shipping airborne radar jamming units to the Air Force.

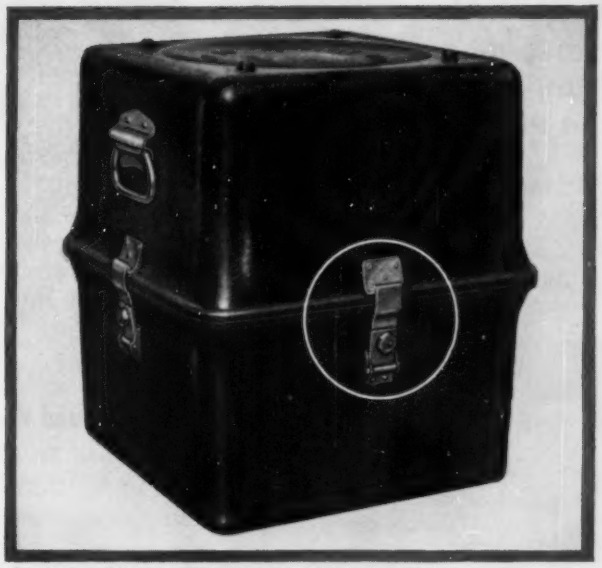
Of prime importance are the container's lightness, strength, rust- and mildew-resistance, ability to withstand high pressures without distortion, ease of locking and opening, and low cost.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

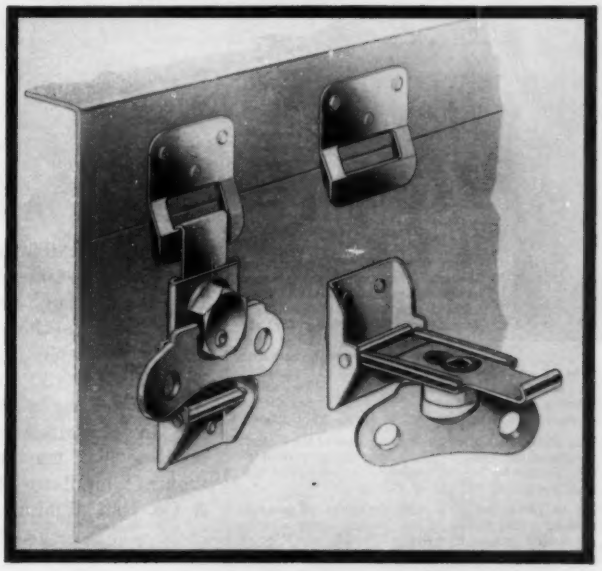
- High closing pressure with light operating torque... insures pressure-tight seals where required.
- Impact and shock resistant (positive-locking).
- Compact design...lays flat against case even when unlocked.
- Available in 3 sizes, for heavy, medium, and light duty.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design...can be varied to suit different conditions.

Also available! Spring-Loaded LINK-LOCK... ideal for less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

Where does the versatile Simmons LINK-LOCK belong in your design? For full information and specifications, send for LINK-LOCK DATA SHEETS today. Samples and engineering service available upon request.



Courtesy of Pressurform Container Corp., and the LMEE Dept. of General Electric Co.



SIMMONS
FASTENER CORPORATION
1756 North Broadway, Albany 1, New York
QUICK-LOCK SPRING-LOCK ROTO-LOCK LINK-LOCK DUAL-LOCK

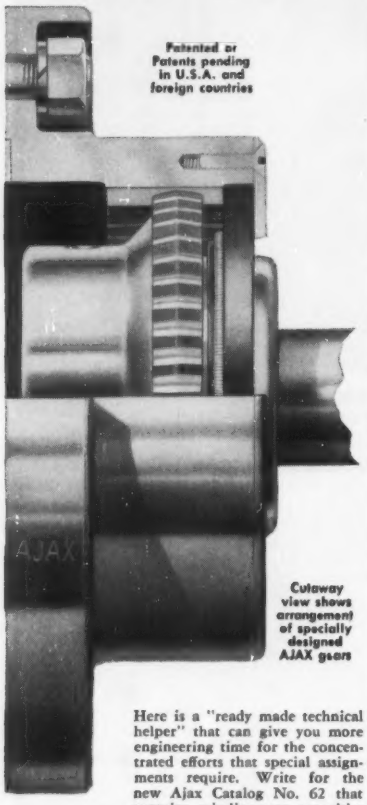
Circle 543 on page 19

AJAX

Self-aligning

DIHEDRAL COUPLINGS

Give Design Engineers An Immediate Source of Product Improvement

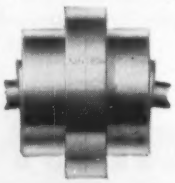


Cutaway view shows arrangement of specially designed AJAX gears

Here is a "ready made technical helper" that can give you more engineering time for the concentrated efforts that special assignments require. Write for the new Ajax Catalog No. 62 that contains misalignment capacities of every coupling size and type in the complete line of Ajax Dihedral Couplings. Why spend valuable time duplicating data already established by thousands of proven, field tested applications.

Ajax Dihedral Couplings handle unavoidable shaft misalignment, angular and offset, up to a total of 12°. Teeth can be cut to handle greater misalignment capacities on special order.

Get the facts on how manufacturers of presses, machine tools, rolling mills, cranes, earth moving and many other direct connected machines are simplifying design, cutting manufacturing costs and improving product performance with Ajax Dihedral Couplings.



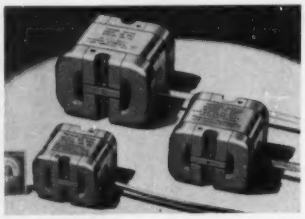
Write today for your personal copy of Bulletin No. 62.

AJAX FLEXIBLE COUPLING CO. INC.
WESTFIELD, NEW YORK

Circle 544 on page 19

New Parts

three sizes. Model 28 produces a force of 13½ lb with ±0.015-in. stroke. Model 24 has force output of 8 lb and ±0.008-in. stroke. Smallest unit, Model 23, produces



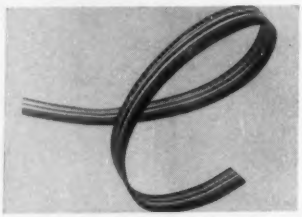
5 lb force with ±0.007-in. stroke. High - temperature models are available for continuous operation to 400 F. **Raymond Atchley Inc.**, 2340 Sawtelle Blvd., Los Angeles 64, Calif.

Circle 772 on page 19

Vinyl Insulated Wire

in gages of No. 26 to No. 20 with 0.009-in. wall

Extruded, semirigid vinyl insulated wire, designated Turbo Tufflex, eliminates the need for nylon jacketing or textile overbraiding. It is



extremely flexible and eliminates wrinkling, creasing and fracturing. It has slightly better electrical characteristics than jacketed wire and is available in gages of No. 26 to No. 20 with 0.009-in. wall. Wire has a 300-v rating for use in electrical accounting and bookkeeping machines and electronic computers. **William Brand & Co. Inc.**, Willimantic, Conn.

Circle 773 on page 19

Adjustable Speed Drives

use electronic tubes for rectification

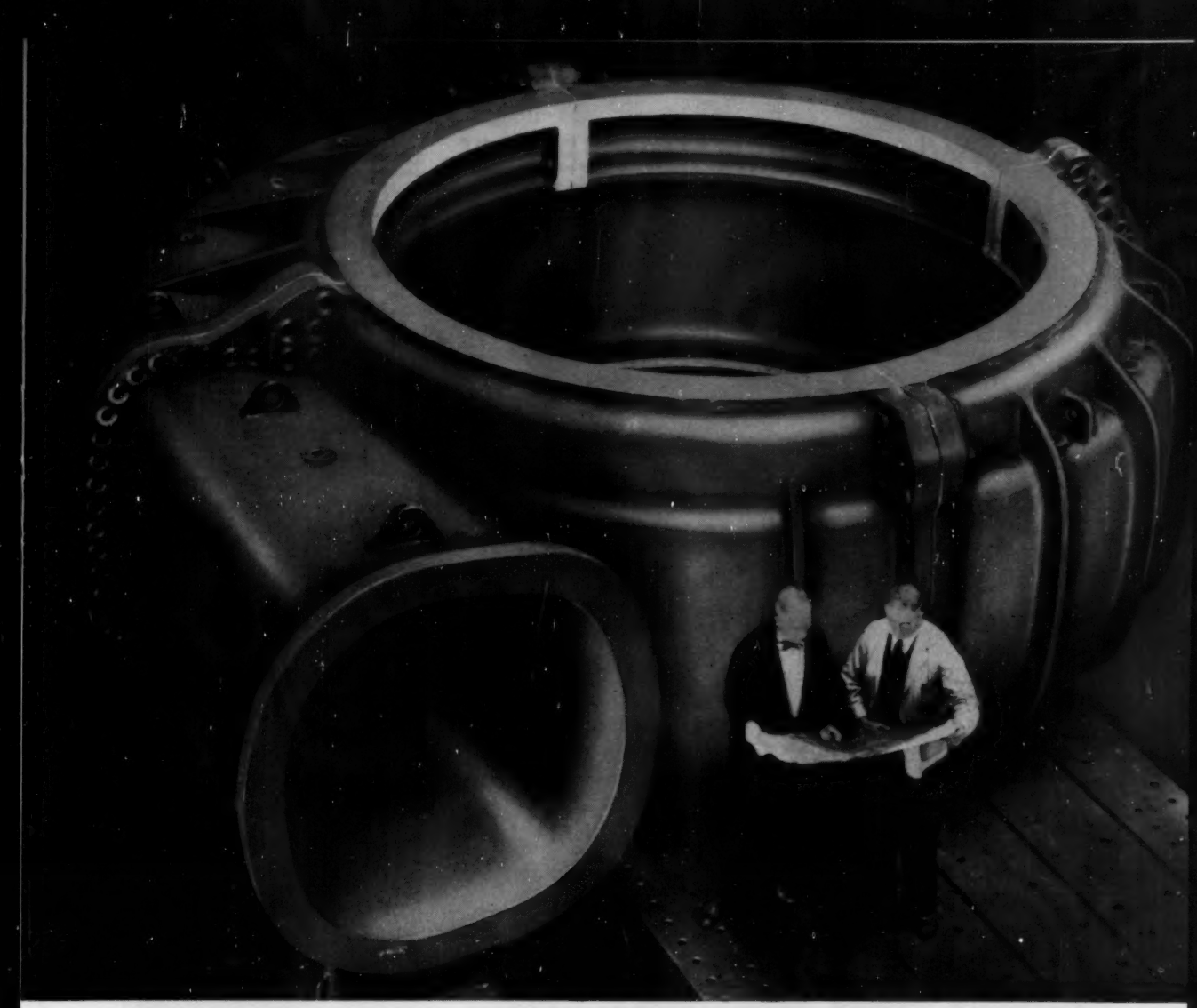
Electronic adjustable speed dc drives in five sizes from ¾ through 3 hp provide electronic control of dc motors from ac power. Adjustable speed range is 50:1 without

MEEHANITE CASTINGS ARE MADE ONLY BY MEEHANITE FOUNDRIES

The American Laundry Machinery Co., Rochester, N. Y.
Atlas Foundry Co., Detroit, Mich.
Banner Iron Works, St. Louis, Mo.
Barnett Foundry & Machine Co., Irvington, N. J.
Blackmer Pump Co., Grand Rapids, Mich.
Centrifugally Cast Products Div., The Shenango Furnace Co., Dover, Ohio
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
Empire Pattern & Foundry Co., Tulsa, Okla.
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machines Co., Inc., Cleveland, Ohio
General Foundry & Mfg. Co., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundry Co., Chicago, Ill.
The Hamilton Foundry & Machine Co., Hamilton, Ohio
Hardinge Company, Inc., New York, N. Y.
Hardinge Manufacturing Co., York, Pa.
Johnstone Foundries, Inc., Grove City, Pa.
Kanawha Manufacturing Co., Charleston, W. Va.
Koehring Co., Milwaukee, Wis.
Lincoln Foundry Corp., Los Angeles, Calif.
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
Pohlman Foundry Co., Inc., Buffalo, N. Y.
The Prescott Co., Menominee, Michigan
Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Sonith Industries, Inc., Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Stearns-Roger Mfg. Co., Denver, Colo.
Valley Iron Works, Inc., St. Paul, Minn.
Vulcan Foundry Co., Oakland, Calif.
Washington Iron Works, Seattle, Wash.
Dorr-Oliver-Long, Ltd., Orillia, Ontario
Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

WRITE TODAY FOR YOUR FREE SINGLE COPY

• **"MEEHANITE CASTINGS FOR PRESSURE TIGHTNESS" BULLETIN NO. 43**



This huge casing for an 84" volute pump was cast in four sections in high strength (over 50,000 psi) Meehanite metal.

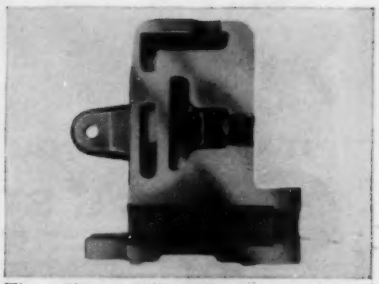
Pressure tight Meehanite castings are uniformly sound and possess high strength values

Meehanite metals provide designers, production men and engineers with a group of dependable materials that possess the superior combination of physical properties required by pressure tight castings used with water, oil, steam, gas and other substances.

The consistent uniformity of the structure of Meehanite metal throughout all casting sections insures excellent performance in service and offers positive freedom from leaks, porous zones and structural weakness.

In addition, Meehanite castings provide high strength values in the order of 55,000 lbs. psi and have a true modulus of elasticity which is important in computing bursting stress.

If you would like to know more about the advantages of Meehanite metal, write today for your free copy of bulletin #43 "Meehanite Castings for Pressure Tightness."



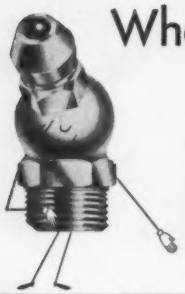
The uniform solidity and closeness of grain through all complex sections are revealed in this cross section of a Meehanite hydraulic valve unit.

MEEHANITE BRIDGES THE GAP BETWEEN CAST IRON AND STEEL®

MEEHANITE METAL

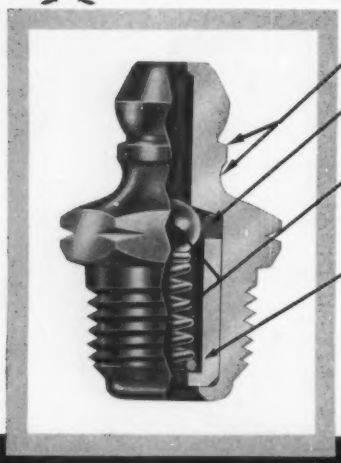
MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK

Circle 545 on page 19



Where **LUBRICATION LEAKAGE** is a Problem

"LITTLE LUBE" recommends our new Double-Check Leak-Proof Grease Fitting

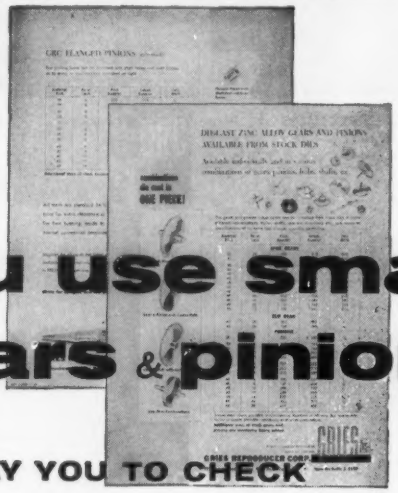


- Patented free release shoulder and groove.
- Resilient "O" ring washers, huge surface of ball, lets grease in, but not out.
- Ball and spring in normal position act as a double check with "O" ring regarding back pressure leakage.
- Steel insert firmly supports "O" ring during service lubrication.

See our complete line of Hydraulic Ball-in-Head Grease Fittings in SWEET'S Product Design File—or write for our new Engineering Data Catalog.

UNIVERSAL LUBRICATING SYSTEMS, Inc.
642 Allegheny Avenue Oakmont, Pennsylvania

Circle 546 on page 19



if you use small gears & pinions

IT WILL PAY YOU TO CHECK

GRC'S STOCK SHEET

Before you order gears or pinions, see GRC's new Stock Sheet. All items listed are cast from stock dies, individually or in various combinations of gears, pinions, hubs, shafts, etc. Holes, shafts spacers, shoulders, etc., are made to your exact specifications at no extra tool charge, quantity permitting. Maximum O.D. about 1½" with ¼" face width; wider faces for smaller diameters. • Unusual shapes, extra precise requirements, available on special order.

WRITE TODAY for new stock sheet and samples. SEND SPECIFICATIONS FOR PROMPT QUOTATION — 100,000 TO MILLIONS

World's Foremost Producer of Small Die Castings

GRIES REPRODUCER CORP.

32 Beechwood Ave., New Rochelle, N. Y. • Phone NEw Rochelle 3-8600

See GRC in LA! Western Metals Show, Booth 617

Circle 547 on page 19

New Parts

field weakening, providing speeds from 35 to 1750 rpm. Motor speed varies not more than ½ of 1 per cent of full speed at any setting

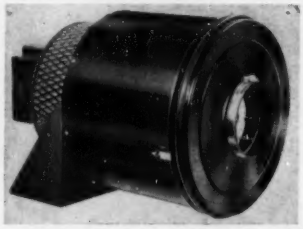
when load is varied from no load to full load. Drive motor is used as a tachometer, reducing the size of the cabinet area normally required for a tachometer and its gearing. **Weltronic Co.**, 19500 W. Eight Mile Rd., Detroit 19, Mich.

Circle 774 on page 19

Centrifugal Blowers

have three to nine cascaded pressure stages

Multistage centrifugal blowers deliver 25 to 350 cfm at static pressures of 10 to 55 in. water column (2 psi) on suction or pressure. They incorporate three to nine cascaded pressure stages, have no



wearing parts, and are direct-coupled to a ¼ to 2-hp induction motor which is an integral part of the unit. Noise levels are low since shaft speed of the blower is only 3400 rpm. Motors are wound single or three-phase for all standard line voltages. Blowers, which are small and lightweight, have electronic, instrument and computer applications. **Rotron Mfg. Co.**, Schoonmaker Lane, Woodstock, N. Y.

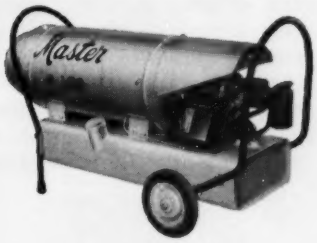
Circle 775 on page 19

Pressure Switches

for pressure to 500 psig pass MIL-E-5272A

Three switches in the Glennite line include: Model 501-A, a differential

Master B-100 Portable Space Heater
MANUFACTURED BY MASTER VIBRATOR COMPANY DAYTON, OHIO



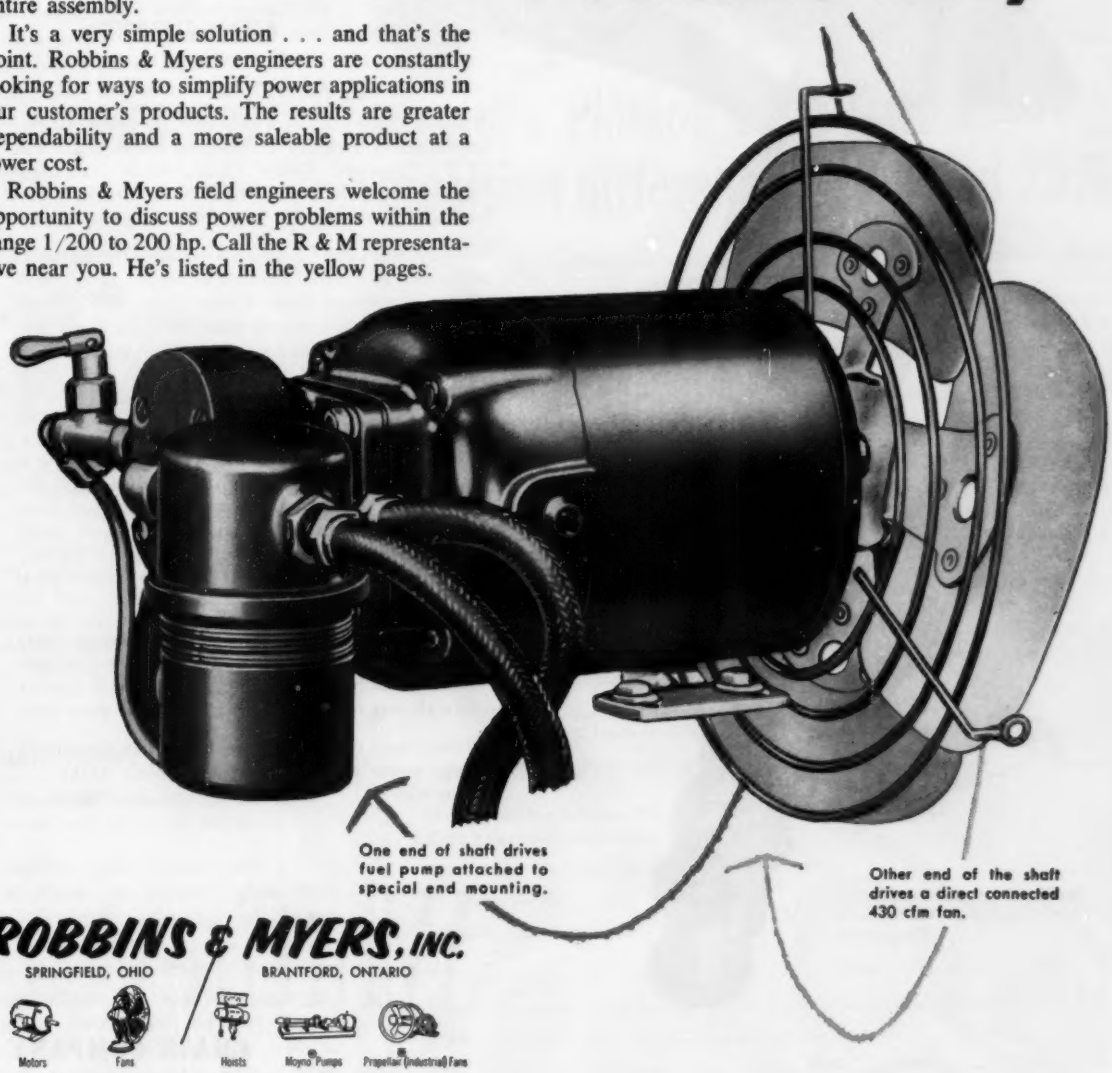
R&M motor does double duty

To accomplish compactness, simplicity and lower cost, this enclosed ¼ hp., 3450 rpm split phase Robbins & Myers motor was specially designed to do two important jobs in the Master B-100 Portable Space Heater.

A special face mounting accommodates a direct driven fuel pump. The other end of the shaft drives a direct connected fan with an output of 430 cfm. A rigid foot mounting on the motor supports the entire assembly.

It's a very simple solution . . . and that's the point. Robbins & Myers engineers are constantly looking for ways to simplify power applications in our customer's products. The results are greater dependability and a more saleable product at a lower cost.

Robbins & Myers field engineers welcome the opportunity to discuss power problems within the range 1/200 to 200 hp. Call the R & M representative near you. He's listed in the yellow pages.


One end of shaft drives fuel pump attached to special end mounting.
Other end of the shaft drives a direct connected 430 cfm fan.

ROBBINS & MYERS, INC.
SPRINGFIELD, OHIO / BRANTFORD, ONTARIO

Circle 548 on page 19

NEW CONCEPTS . . .

Whitney Chain engineers have recently developed two revolutionary designs . . . Self-Lube Roller Chain and "F-R" Processed Roller Chain. Each completely proven in the field, these chains can open entirely new cost-saving concepts for your drive-design programs.

Whitney Self-Lube Chain outlasts regular chain by as much as 5 to 1 under continuous service in extremes of dust or moisture. Here, Whitney's exclusive sintered steel bushings "oil cleanly from the inside", are prelubricated for life, cannot trap abrasive matter which cuts chain life. Ideal for applications in food, drug, textile and many industries where ordinary chain lubrication results in product damage.

And Whitney's new "F-R" Processed Roller Chain is establishing new service standards for durability, particularly on problem drives involving unusual operational conditions, stresses and heavy shock loads. This performance comes from the exclusive Whitney "F-R" process which offsets excessive operational stresses in the chain.

These new chains with dynamic, balanced design, serve better, longer and at less over-all cost . . . and so does Whitney's entire line of chain . . . developed by specialists with over 60 years' know-how in *your* drive field.

Whitney field engineers, warehouses, and alert distributors assure top service from complete stocks . . . nation-wide. Write for full technical literature.

Whitney

CHAIN COMPANY

205 HAMILTON ST., HARTFORD 2, CONN.

ROLLER CHAIN • SILENT CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS

Circle 549 on page 19

pressure switch designed to make or break electrical circuits when the difference between two pressures is equal to or greater than a predetermined value; a gage pressure switch, Model 301-A; and an altitude switch, Model 101-A. Dif-

ferential pressure switch has low and high operating pressures of 250 and 500 psig respectively and weighs 0.75-lb. Pressure differential is sensed by a diaphragm-type capsule that withstands high overpressure without sacrificing sensitivity. All switches pass environmental test MIL-E-5272A. **Gulton Industries Inc.**, 212 Durham Ave., Metuchen, N. J.

Circle 776 on page 19

Nameplate Decals

for difficult surface applications

Meyercord Type I nameplate decals adhere instantly and permanently to any commercial surface including acrylics, polyethylene and unpainted metals. Water applied, the decals do not depend upon water solubility for adhesion, and accidental oversoaking will not affect adhesive qualities. Nameplates can be designed with halftones or in poster style. **Meyercord Co.**, 5323 W. Lake St., Chicago 44, Ill.

Circle 777 on page 19

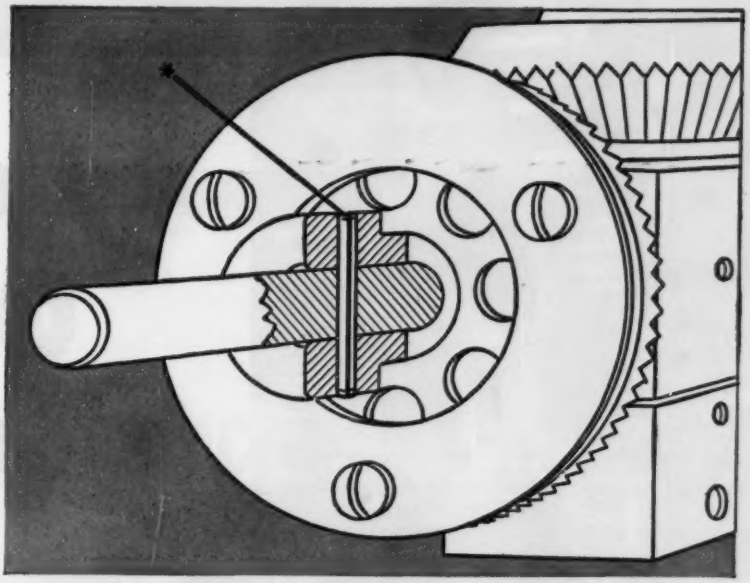
Plastic Panels

are reinforced with aluminum or steel mesh

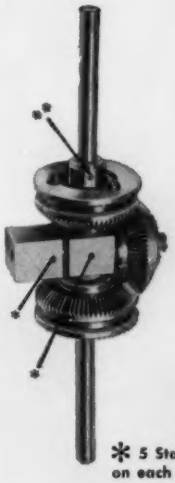
Security Junior translucent panels are clear or colored glass-fiber plastic with embedded aluminum or steel diamond mesh. They offer unusual architectural design possibilities, as well as semitransparent protection against flying particles and liquid spray. Metal mesh reinforcement provides high

(*Continued on Page* 244)

FASTENER PROBLEM



Pinning costs for precision differentials reduced 25%



Using taper pins for assembly of these three precision differentials presented a cost-reduction problem to the PIC Design Corp. Tool cost, for example, was high because taper pins require fine, perishable and expensive taper pin reamers. Assembly costs, of course, were increased by the added reaming operation.

PIC replaced taper pins with Rollpin in all assemblies and cut fastening assembly time and costs substantially. The high cost of reaming has been eliminated entirely because Rollpin is a pressed-fit, slotted tubular steel pin which drives easily into holes drilled to normal production tolerances. Made slightly oversize, Rollpin compresses as driven. Its spring action locks it in place—withstanding impact loading, stress reversals, and severe vibration. And base price of stainless steel Rollpin is far lower than the equivalent taper pin.

If you use dowels, pins, rivets, or set screws and want to maintain high shear strength, consider the probability that Rollpin can cut your costs, too.

✻ 5 Stainless Steel Rollpins used on each PIC Precision differential.

ROLLPIN TRADEMARK

MAIL THIS COUPON FOR DESIGN INFORMATION

Elastic Stop Nut Corporation of America, Dept. R44-34 (D.N.)
2330 Vauxhall Road, Union, New Jersey

Please send me the following free fastening information:

☐ Rollpin Bulletin

☐ Elastic Stop Nut Bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

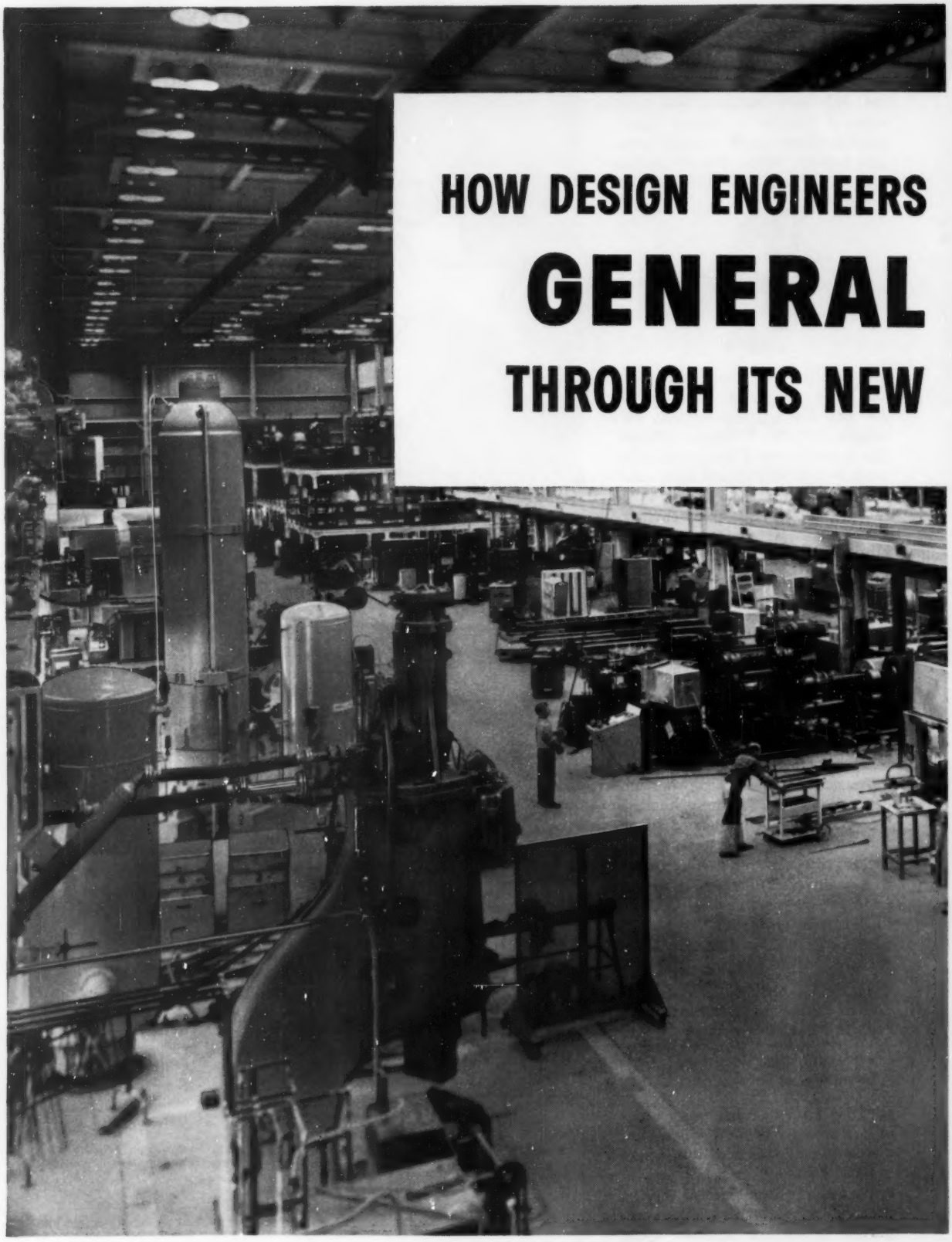
Name_____ Title_____

Firm_____

Street_____

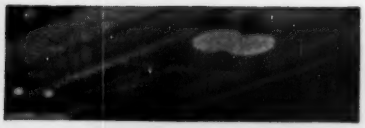
City_____ Zone____ State_____

Circle 550 on page 19



HOW DESIGN ENGINEERS GENERAL THROUGH ITS NEW

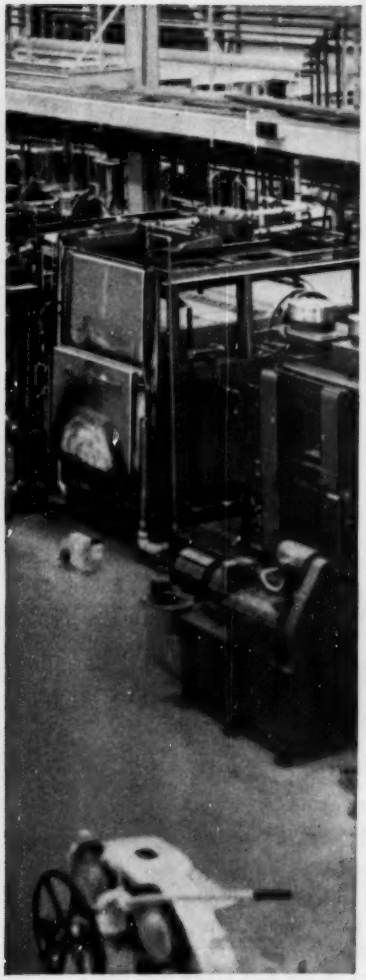
Laboratory with factory-size equipment – that's the new $5,000,000 G-E metals and ceramics laboratory in Schenectady. From here will come many of the products manufactured by the Metallurgical Products Department of General Electric Company, 11126 E. 8 Mile Road, Detroit 32, Michigan.



BENEFIT FROM THE RESOURCES OF

ELECTRIC

METALLURGICAL PRODUCTS DEPARTMENT



Solutions to your most pressing problems — plus developments ahead of industry trends — are now being worked out in our laboratories

Because designers needed a metal harder and more wear-resistant than steel, General Electric brought out Carboloy® cemented carbides. Because designers needed a more powerful magnetic material, General Electric developed improved types of Alnico permanent magnets. Because designers needed better high-temperature metals, General Electric created new vacuum-melted alloys.

These, and many other vital products for design engineers, are the result of General Electric's tremendous resources of technological know-how and skilled manpower in the field of metallurgy. They are created in G-E laboratories . . . and produced for industry by the new Metallurgical Products Department.

This Department is the successor to the Carboloy Department, which was originally organized to manufacture carbides. It now produces such widely divergent metallurgical products as hevimet, thermistors, and Thyrite® varistors . . . in addition to chrome and tungsten carbides, and permanent magnets.

The very range of its products indicates how the resources of General Electric are being put to work solving the design engineer's most pressing problems through modern metallurgy.

Perhaps more important, G-E resources like the new Research Laboratory in Schenectady, and the manufacturing facilities of the Metallurgical Products Department, are now combining their talents to produce *ahead* of the trends and needs of industry.

In the Metalworking Industry, for example, this combination of G-E resources has already made one such contribution: Carboloy Cemented Oxide — a new kind of cutting tool material with so great a potential for super high-speed machining, that new machine tools must be designed to take advantage of all it offers.

Developments like these are essential to industrial progress . . . and they are typical of the parade of products design engineers can expect from the G-E Metallurgical Products Department.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 551 on page 19

No load is big enough to stall the engine when the tractor has a National Supply torque converter. 17 basic sizes available to match exactly engines of 100 to 1000 horsepower.

Easy way to tell if a heavy-duty machine needs a torque converter

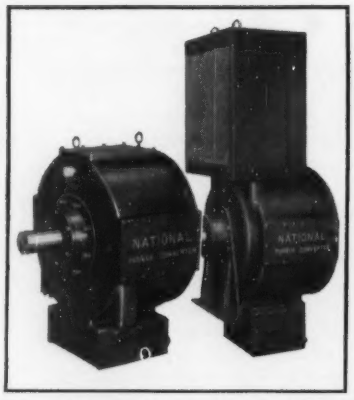
You can tell simply by listening to the engine while the machine is operating. Does it run fast—then slow down as the load builds up—then drop off to idling speed—then start all over again? If so, a National Supply torque converter would probably make the machine make more money for you.

A National Supply torque converter lets the machine work at full capacity all the time. The engine never labors or stalls because of overload. Instead, it runs continually in its best speed range and delivers its full horsepower at all times.

The torque converter automatically increases or decreases the flow of power as required by each change in the load. Many little delays and losses are eliminated.

Your machine gets more work done in a day. Also, because of the shock-cushioning effect of the National Supply torque converter, there's less engine maintenance . . . less wear and tear on equipment.

If you operate heavy-duty machinery, you should look into torque converters. National Supply, with experience in the application of high-power fluid transmission since the 'thirties, can help you. Write to have a National Supply engineer analyze your problem and figure the results you can expect from a torque converter. The National Supply Company, Two Gateway Center, Pittsburgh 22, Pennsylvania.



National Torque Converters are manufactured with or without integral cooling systems.

THE NATIONAL SUPPLY COMPANY

INDUSTRIAL PRODUCTS DIVISION

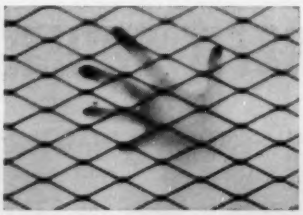
Two Gateway Center, Pittsburgh 22, Pa.

Pace-setters in the progress of industrial power transmission

New Parts

(*Continued from Page* 241)

impact resistance. In aluminum, the panels consist of 0.081 gage expanded aluminum embedded in flat Resolite sheets using 1½ oz



glass fiber mat. In steel, they are 16-18 gage expanded steel embedded in flat plastic sheet. Average light transmission value is 50 per cent. Panels are available in lengths of 8 and 10 ft and widths of 1, 2, 3 or 4 ft. **Resolite Corp.**, Zelienople, Pa.

Circle 778 on page 19

Casters

have wing-type wheel brake

Diamond Arrow casters in 4 and 5 in. sizes, used in plate or stem construction on light work stands, portable ladders, conveyor sections

and other mobile equipment, are equipped with a wing-type wheel brake which enables caster wheel to be locked securely or released with a touch of the toe. **Bassick Co.**, Bridgeport 2, Conn.

Circle 779 on page 19

Beryllium-Copper Strip

is free from surface oxides

Oxide-free beryllium-copper strip for use in electronic, electrical, aircraft, instrumentation and other industrial equipment can be stamped in the soft stage and heat-hardened. It has excellent electrical and spring characteristics, making it suitable for current-

Circle 552 on page 19

Circle 553 on page 19→

Sky Steel

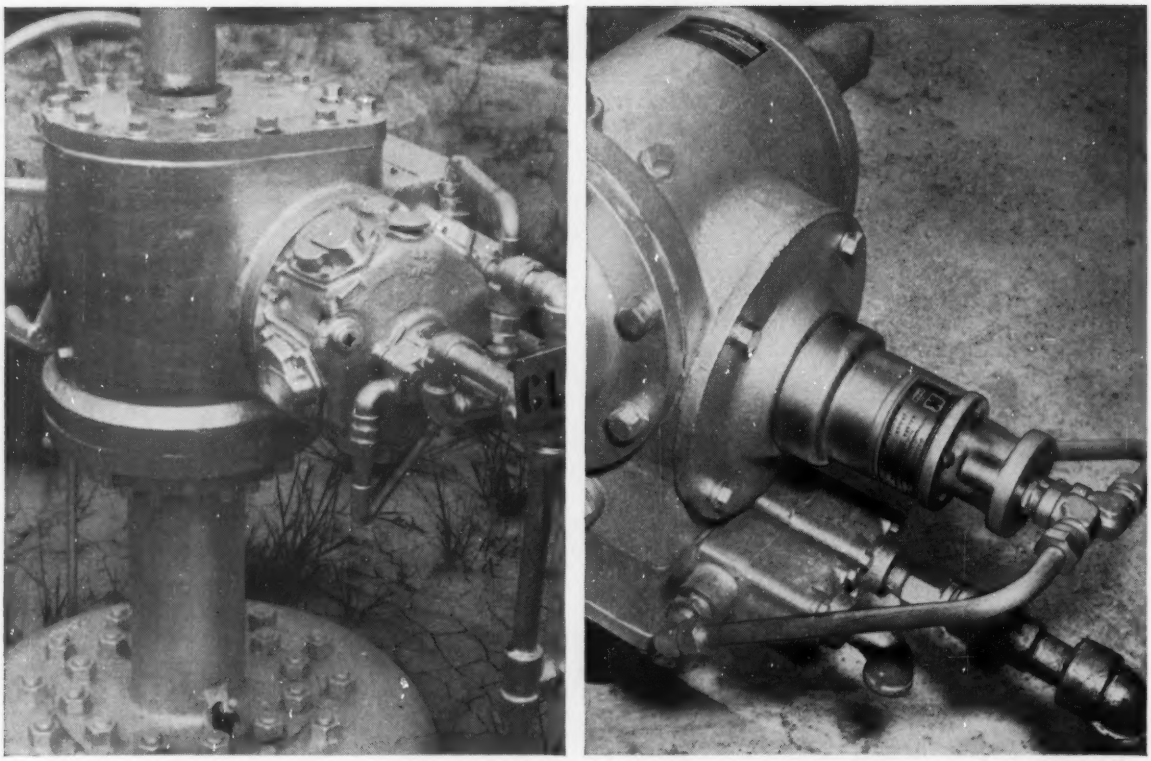
Aircraft design today is a challenge unequalled in any period of the past. The exacting requirements to produce a superior result have pushed metallurgy and metal working beyond traditional practice.

The designer less often selects from standards but rather proposes new shapes and new materials to produce results beyond traditional thinking.

Cameron's contribution to this era has been the development of an unusual forging process for large, intricate ferrous components. Elimination of welds, better grain structure, internal as well as external curvatures, and considerable machining economy are making these remarkable "Sky Steel" forgings more popular every month. For complete information write or call . . .

Cameron
IRON WORKS, Inc.
P. O. Box 1212, Houston, Texas
SPECIAL PRODUCTS DEPARTMENT

OUR LIST OF CUSTOMERS INCLUDES: BENDIX PRODUCTS DIVISION, BENDIX AVIATION CORPORATION • CLEVELAND PNEUMATIC TOOL COMPANY • CURTISS-WRIGHT CORPORATION • FORD MOTOR COMPANY, AIRCRAFT ENGINE DIVISION • GENERAL ELECTRIC COMPANY, AIRCRAFT GAS TURBINE DIVISION • HAMILTON STANDARD DIVISION, UNITED AIRCRAFT CORPORATION • I-T-E CIRCUIT BREAKER COMPANY • H. W. LOUD MACHINE WORKS, INC • PRATT AND WHITNEY AIRCRAFT • RHEEM MANUFACTURING COMPANY • RYAN AERONAUTICAL COMPANY • SOLAR AIRCRAFT COMPANY • THOMPSON PRODUCTS, INC. • WESTINGHOUSE ELECTRIC CORPORATION, AVIATION GAS TURBINE DIVISION

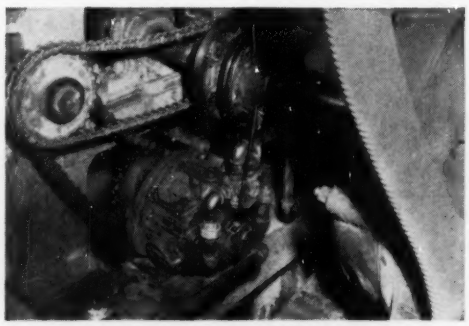


Safe, remote control of natural gas lines, using air motors to operate valves. Left: Gardner-Denver five-cylinder radial air motor on 24" valve. Right: Keller Tool axial piston air motor. Both motors operate on natural gas at line pressure.

No fire hazard with these air motors

Think of air motors when the specs call for rotary power in gassy, dusty, fire hazardous spots. Air motors can't spark. They won't burn out when overloaded—merely stall. They don't heat up under constant starting, stopping, reversing.

And when you think of air motors, remember Gardner-Denver and Keller Tool offer a complete line of *quality* air motors from ½ hp to 16 hp. Five-cylinder radial, axial piston, and rotary vane types. Send for descriptive bulletins.



Midst the wood dust of sawmills, Gardner-Denver five-cylinder radial air motors are frequently used for powering edger feed rolls.

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

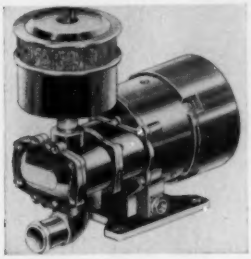
carrying springs. In ultra-thin and extremely close tolerance gages, material has many applications in miniaturized electrical and electronic components. It is available in thicknesses down to 0.0005-in., in tolerances as close as ±0.0001-in., in widths from 3/32 to 6 in., and in quantities from 1 lb. **American Silver Co. Inc.**, 36-07 Prince St., Flushing 54, N. Y.

Circle 780 on page 19

Dry-Air Pump

compact and lightweight unit delivers 30 cfm

Model 133218 positive-displacement dry-air pump incorporates patented features at tips and ends of impellers to provide practically zero clearance without rubbing. Oil-free, the pump is compact and



weighs 5 lb 10 oz. It is rated at 40 cfm zero-pressure delivery or 30 cfm (free air), 10 psi delivery at 7500 rpm. Higher pressures can be attained, and pump speed can be increased if more flow is desired. Motor is continuous-duty, totally-enclosed type rated 2.8 hp at 7500 rpm. **Borg-Warner Corp.**, Pesco Products Div., 24700 N. Miles Rd., Bedford, O.

Circle 781 on page 19

Power Transmitter

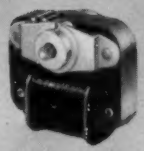
controls motor stop-start to 40 starts per min

Rapid stop-start machine operation is remotely or automatically controlled by solenoid-operated power transmitter. Forty or more starts per minute may be achieved if inertia is sufficiently low. Motor uses constantly running motor-driven flywheel with short-throw clutch. Actuation is by two tandem-arranged, 115-v, ac solenoids. One engages clutch; other

THE MARK OF QUALITY

BARBER COLMAN

Small Motors



TYPE DYAB

"We needed a quality motor with long life for our new automatic ice maker."

Servel Inc., Evansville, Indiana

The Automatic Ice Maker on the new Servel gas refrigerator keeps a constant supply of individual ice cubes readily at hand, so that they may be taken out singly or in quantities as needed. Everything is automatic . . . water is piped to the unit, single cubes drop down ready for use . . . no bothersome tray-filling, no separating of cubes. To activate this Automatic Ice Maker, Servel Inc. standardizes on the Barber-Colman Type DYAB Small Motor with "Plus" features of high starting torque . . . long life . . . rugged construction . . . hardened and ground stainless steel shafts . . . porous bronze bearings . . . generous oil reservoirs. If you have a design problem involving small motors, let Barber-Colman engineers help you solve it with the exact motor for the job.

FREE HELPFUL DATA SERVICE on the complete line of Barber-Colman small motors which includes unidirectional, synchronous, and reversible motors — up to 1/20 hp. With and without reduction gearing — open or enclosed types. Expert engineering service available. Write today, tell us your problem, ask for free data sheets and catalog F-4271-6.

REVERSIBLE SYNCHRONOUS GEARED UNIDIRECTIONAL

BARBER-COLMAN COMPANY

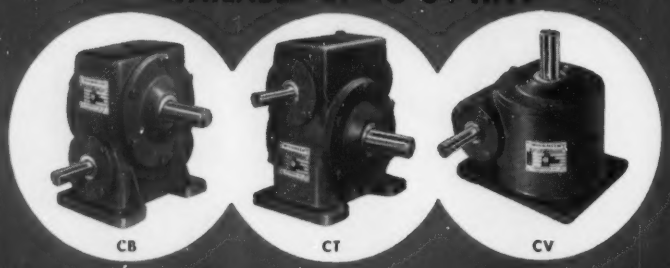
Dept. O, 1273 Rock Street, Rockford, Illinois

Small Motors • Automatic Controls • Industrial Instruments • Aircraft Controls
Electrical Components • Air Distribution Products • Overdoors and Operators
Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

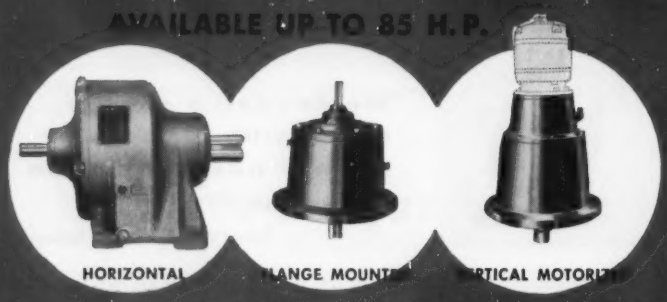
Circle 555 on page 19

VERSATILE PERFORMANCE
for your BIG JOBS, too,
in SPEED REDUCTION

WINSMITH WORM GEAR REDUCERS
AVAILABLE UP TO 34 H.P.



WINSMITH DIFFERENTIAL REDUCERS
AVAILABLE UP TO 85 H.P.



The stock line of Winsmith Speed Reducers offers a wide variety of rugged, heavy duty units designed to handle *all your* speed reduction problems involving high input horsepower. Worm gear reducers are available in horizontal or vertical types, with right angle or parallel shafts . . . worm on top or worm on bottom. The Winsmith Differential line offers equal versatility with three stock types — Horizontal, Flange Mounted, or Vertical Motorized.

It will pay you to standardize on Winsmith — the most complete line for all your speed reduction jobs — big or small — from 85 h.p. down to 1/100 h.p.

WINSMITH SPEED REDUCERS

COMPLETE ENGINEERING DATA on hundreds of types and sizes of Winsmith reducers is included in Catalog #155 — write for your copy today.

WINSMITH, INC. 16 Elton St., Springville, (Erie County), N. Y.

New Parts

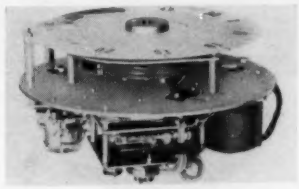
engages brake. Control is accomplished by stop-start push-button station, or can be automatic through use of limit switches, sensing devices, timers or other controls. Unit is available for 115/230 v 60-cycle ac operation in ¼ to 1-hp ratings and for two or three-phase, 60-cycle operation at 208, 220/440 or 550 v with ratings from ¼ to 2 hp. **Diehl Mfg. Co.**, Finderne Plant, Somerville, N. J.

Circle 782 on page 19

Potentiometer Servo-Mechanism

for built in applications

Self-balancing electronic potentiometer servo-mechanism, furnished without case, is designed to be built into user's equipment. When used with amplifier, input trans-

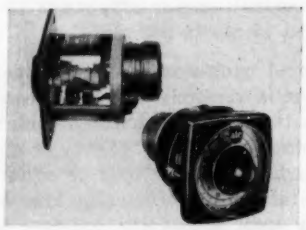


former and dc-ac inverter, unit forms complete self-balancing dial indicator. Dial speeds of 1, 3, and 4½ sec are available. Applications include use as indicating pyrometer, resistance thermometer or potentiometer, or as a unit to operate analog-digital conversion mechanisms for readout. **Bristol Co.**, Waterbury 20, Conn.

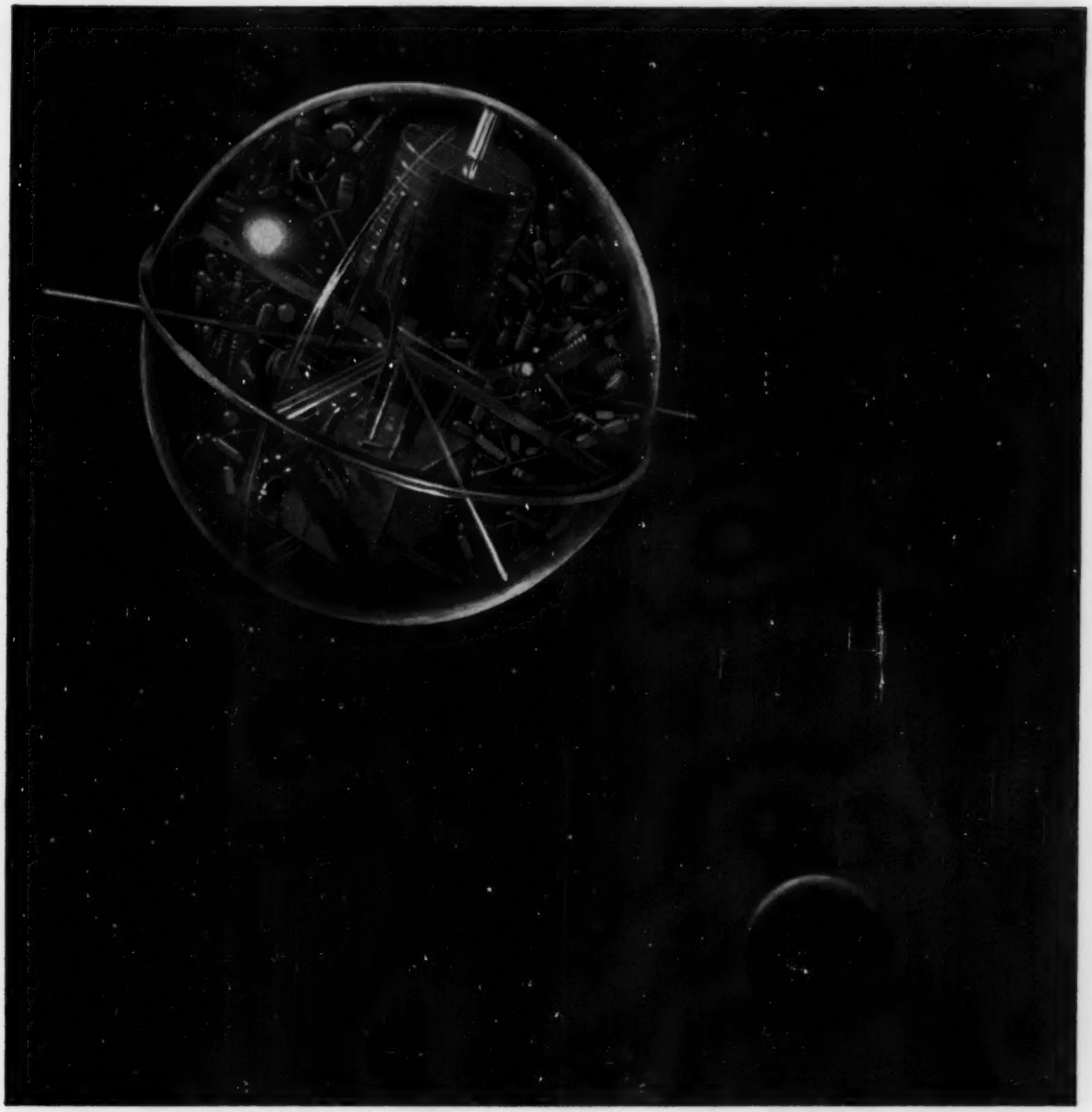
Circle 783 on page 19

Input Controller

offers precise heat control



Electric-current percent-input controller offers high accuracy in control of operating temperatures in ovens, furnaces, and similar ap-



Putting a voice in the man-made moon

America's first man-made satellite will soon be launched into outer space where, traveling in its own orbit, it will circle the earth.

Deep inside will be sensitive electronic instruments which will "observe" cosmic activity and "report" findings back to us. Scientists believe that many a mystery of the universe may thus be solved.

Without electrical insulation of exceptional qualities, such as CDF supplies, the equipment inside these man-made moons could never operate.

FOR SPECIFIC INFORMATION on CDF products, see Sweet's, Electronics Buyers' Guide, and other directories. Then send us your print or your problem, and we'll return free samples and technical literature.

CDF MAKES Dilecto Laminated Plastics • Celoron Molded Plastics • Micabond Mica Products • Diamond Vulcanized Fibre • Flexible Tapes of Teflon*, Silicone, and Micabond • Resin-Impregnated Spiral Tubing • *Complete Fabrication Facilities.*

*duPont trademark for its tetrafluoroethylene resin

CONTINENTAL-DIAMOND FIBRE

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NOW . . .

high efficiency

Filters, Regulators, and Lubricators for Air Supply to Pneumatic Equipment

with the NEW

WATTS high efficiency LINE

consisting of:

WATTS high efficiency FILTER

New TORNADO ACTION

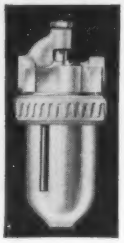
Contoured inlet eliminates drastic air pressure drop and forces the air into a downward spiral. This "Tornado Action" sets up centrifugal force which spirals dirt and moisture particles downward into the "quiet zone."

WATTS high efficiency REGULATOR

New ASPIRATOR ACTION

Watts Aspirator control acts directly on input valve, giving instant compensation for fluctuating pressure demands . . . provides precise control and stabilizes pressures reaching individual pieces of equipment.

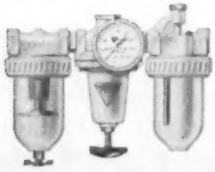
WATTS high efficiency LUBRICATOR



New BY-PASS PICKUP

Watts new By-Pass Pickup makes possible an exclusive high velocity venturi section which vaporizes virtually 100% of the metered oil. By-Pass permits maintenance of constant pressure in the venturi section with minimum pressure loss.

Complete range of Sizes: 1/4", 3/8", 1/2"



BOWLS CAN BE REMOVED IN 30 SECONDS

Write for catalog and specification sheets on WATTS high efficiency line.

WATTS REGULATOR COMPANY SINCE 1875

12 EMBANKMENT ROAD LAWRENCE, MASSACHUSETTS

Circle 558 on page 19

New Parts

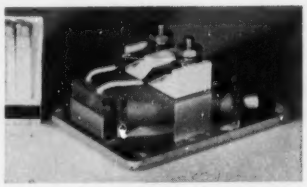
plications. Unit eliminates use of rheostats with consequent dissipation of power load through resistance. Controllers have synchronous motors rated for operation from 115 to 230 v, 25, 50 or 60 cycles. Unit controls temperatures by interrupting heating circuit at regular intervals, adjustable on dial calibrated from 0 to 100 percent "on" time. **Automatic Temperature Control Co.,** 5200 Pulaski Ave., Philadelphia 44, Pa.

Circle 784 on page 19

Fire Detector

withstands 2000 F flame for short periods

Fire detector is a thin-shelled, stainless-steel, hermetically sealed unit weighing 4.3 oz. Unit has temperature adjustment range of 50 to 350 F and can withstand



exposure to −65 F indefinitely and to a 2000 F flame for short periods. Contacts close when temperature exceeds previously set point. Current rating is 5 amp at 125 v ac, 2 amp at 28 v dc, and 1 amp at 48 v dc. **Fenwal Inc.,** Aviation Products Div., Ashland, Mass.

Circle 785 on page 19

Silicone Rubber

has wide temperature operating range

Silicone sponge rubber of 50 durometer-base stock exhibits extreme flexibility at temperatures down to −100 F yet has good heat resistance to 500 F. Style 9383 sponge is extremely tough and resists tearing and abrasions. Aging and weathering qualities are excellent, and material sheds water and resists adhesion of ice. Rubber is available in sheets, rounds and any shape extruded sections. **Garlock Packing Co.,** 405 Main St., Palmyra, N. Y.

Circle 786 on page 19

From Century... completely redesigned Performance-Rated© GEARMOTORS

Here they are... new improved Century Gearmotors ... Performance-Rated for exact application of motor to job... embodying that famous *Century dependability!* Available with Century polyphase, single phase and DC motors. Variety of mounting positions possible, including downshaft and tilted shaft.

Improved equipment performance for you with new improved Century Gearmotors

No pinion play, no creep even under reversing service! Motor shaft machined for high speed pinion assembly... pinion splined into shaft and rigidly, positively locked in perfect alignment!

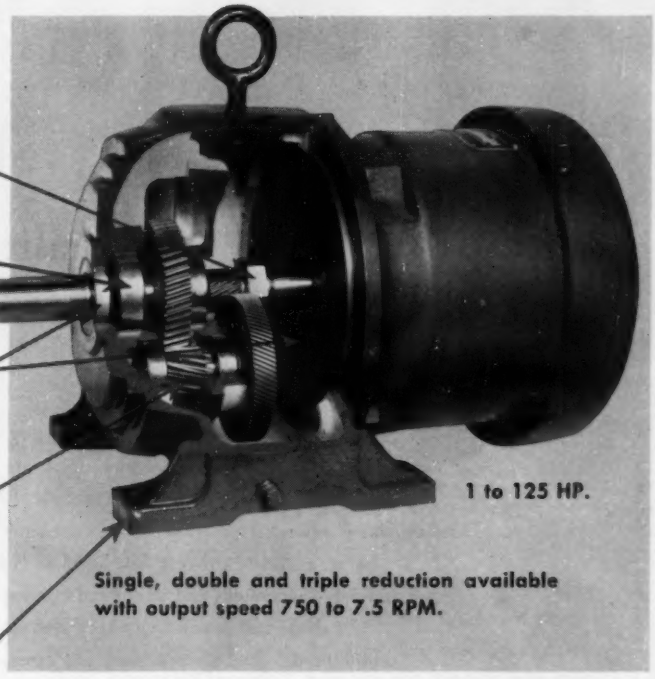
Trouble-free service even under heaviest loads and severest operating conditions is provided by extra-capacity bearings, integral bearing housings.

Cooler operation... maximum wear life, and extra thermal capacity through improved case design and superior oil mist lubrication. Improved oil seals keep the lubricant *in* and foreign matter *out*.

More dependable power transmission... higher capacity and longer wear life with Duti-Rated Lifetime helical gearing. Carefully controlled heat treating processes give file-hard tooth surfaces, tough ductile tooth cores.

Permanently accurate alignment of shafts, gears, bearings and seals assured by extra-rigid, cast gear housing. Alignment can't be distorted by overhung loads, uneven mounting surfaces, impact. Quick easy disassembly for inspection or maintenance without disconnecting from driven equipment.

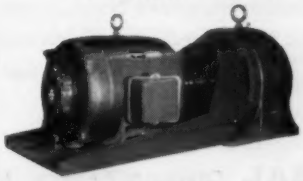
Century Gearmotors are Performance-Rated for precise application to your equipment requirements in the full Century range of motor size, speed, torque, mounting. Available in drip proof, explosion proof or totally enclosed frames.



1 to 125 HP.

Single, double and triple reduction available with output speed 750 to 7.5 RPM.

Century Gearmotor with shelf-type motor base.



Ideal for use on equipment for plants where motors must be interchangeable. Uses Century standard horizontal motor.

Investigate these improved Century Gearmotors now. For further details, call or write your nearby Century District Sales Office or Authorized Distributor.

Performance-Rated© MOTORS 1/20 to 400 HP

CENTURY ELECTRIC COMPANY

63

1806 Pine Street • St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*

Circle 559 on page 19

With National Seals

Quality control isn't a myth— it's a crusade!

At National, quality control is based on the oil seal industry's most rigid manufacturing specifications. It begins with critical examination of raw materials. It includes constant checking of form tools and molds. It extends to exhaustive optical examination of all seal components by an exclusive process developed at National. (In this process, seals are cast and cross-sectioned, and an optical comparator used to show exact shape and position of every seal part, mounted on the shaft or unmounted.) And always, there are extensive and continuing operating and "leak" tests of finished seals.

For proved dependability, specify National seals. And for prompt, knowledgeable help on sealing problems, call your factory-trained National Seal engineer.

NATIONAL SEAL Division, Federal-Mogul-Bower Bearings, Inc.

General Offices: Redwood City, California; Plants: Van Wert, Ohio, Downey and Redwood City, California

National Field Engineers At Your Service: Chicago, Ill., Room 462, McCormick Building, HArrison 7-5163
Cleveland, Ohio, 210 Heights Rockefeller Bldg., YEllowstone 2-2720 • Dallas, Texas, 2520 West Mockingbird Lane, FLeetwood 2-7541
Detroit, Mich., 13836 Puritan Avenue, VErmont 6-1909 • Indianapolis, Indiana, 2802 North Delaware St., WAlnut 3-1535
Milwaukee, Wis., 647 West Virginia Street, BRoadway 1-3234 • Newark, N. J., 1180 Raymond Blvd., MItchell 2-7586

4062

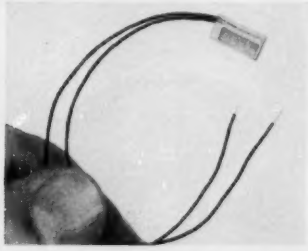
ENGINEERING DEPARTMENT

EQUIPMENT

Resistor

for temperature telemetering

Type 1371 Tape On surface temperature resistor for temperature telemetering can be applied to any surface. Sensing element is applied by pressing thumb over a small piece of mylar tape. Having an output up to 5 v without amplifi-



cation, the resistor can be used directly in a commutation circuit to modulate standard telemetering transmitters. Resistance change over specified temperature range is 100 ohms. Resistor is available in ranges from −300 to 400 F. Size of the unit is ¼ x 5/16-in.; accuracy is ±2 per cent of full scale range. **Trans-Sonics Inc.**, Box 328, Lexington 73, Mass.

Circle 787 on page 19

Nonoverloading Amplifier

output is unaffected by counting rate

Model 155 amplifier is for high counting-rate applications requir-

ing gain stability, linearity and nonoverloading properties. Suitable for use with scintillation and proportional counters, unit will

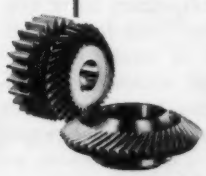
SPECIAL MACHINES —MEN

2 Reasons Behind Brad Foote Quality

• The craftsman shown below is loading a gear into one of the latest additions to BRAD FOOTE'S long list of special-purpose machines. The only one of its kind in existence, this new shaver can straight or crown shave gears up to 51" in diameter. Normally accommodating gears with shafts up to 142" between centers, it can handle even longer shafts by using special journals. Specially designed, the new machine will shave either internal or external gears.

• Costly special machines such as this are important in providing the extra quality at lowest cost which is the hallmark of BRAD FOOTE gears. But these are only part of the story. Even more important, perhaps, are the men who man these machines—experienced craftsmen with long experience in producing gears to meet the most exacting and specialized requirements.

• BRAD FOOTE'S facilities are at your disposal whether you need one gear or a long production run. We would sincerely appreciate an opportunity to discuss your requirements or quote on your specifications. Your inquiry will receive prompt attention.



BRAD FOOTE GEAR WORKS, INC.

1308 South Cicero Avenue • Cicero 50, Illinois
Bishop 2-1070 • Olympic 2-7700 • TWX: CIC-2856-U

subsidiaries

AMERICAN GEAR & MFG. CO.
Phone: Lemont 920
Lemont, Illinois

PITTSBURGH GEAR COMPANY
Phone: SPalding 1-4600
Pittsburgh 25, Pennsylvania

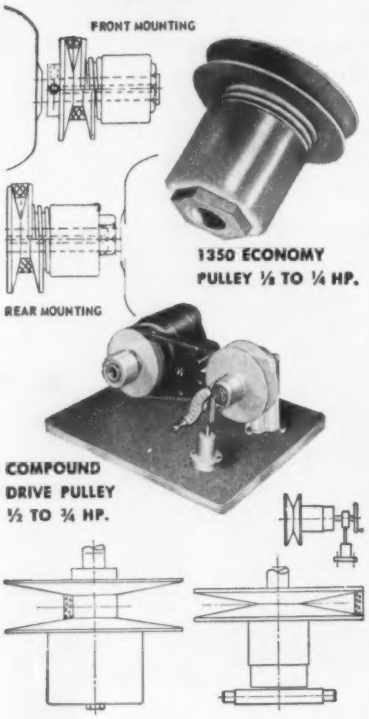
Circle 561 on page 19

Circle 560 on page 19

Lovejoy

Fractional Horsepower

VARIABLE SPEED PULLEYS



Economical—
low in initial cost . . . easily installed on old or new equipment.

Minimum Maintenance—
simple construction assures trouble-free operation . . . lifetime lubricated with oil-impregnated bronze bushings.

Constant Belt Alignment—
inner and outer pulley sheaves open equally to provide smooth, infinitely variable speed ratios to 8 to 1.

No Slippage—
Sure grip of belt sides delivers full traction under all load conditions...result is greater horsepower carry capacity.

Get the new 12-page Lovejoy catalog! Write today.

LOVEJOY FLEXIBLE COUPLING CO.
4818 W. Lake St., Chicago 44, Ill.

Circle 562 on page 19

Engineering Equipment

trigger at 1.5 megacycles. Signal emitted may be fed to external fast scalers or coincidence circuits. **Beva Laboratory**, Box 478, Trenton, N. J.

Circle 788 on page 19

Temperature Test Chamber

has testing range from −65 to 600 F

Model TC-4 temperature test chamber for ambient testing of products up to 600 F has a product capacity of 600 cu in. of working space and testing range from −65 to 600 F. Each test tray is provided with fifteen 3/8-in. diameter openings for electrical or mechanical conections to the product under test. Unit is compactly designed for portability. Anticipator-type thermostat limits maximum temperature fluctuations to less than 4 F. Heating element is two 750-w finned strip heaters, and dry ice is used for cooling. Electrically operated blower assures continuous circulation and complete mixing of air within test chamber. **Statham Development Corp.**, 12411 West Olympic Blvd., Los Angeles 64, Calif.

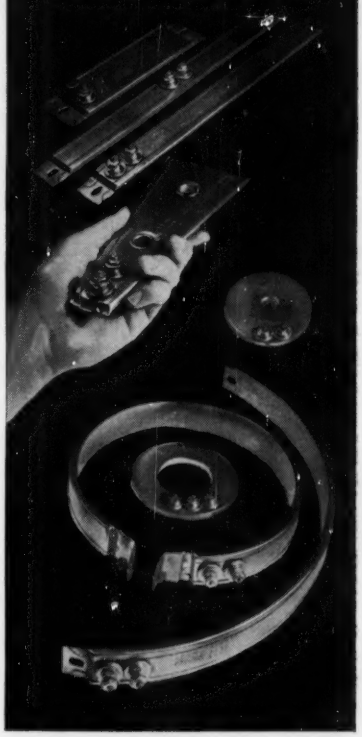
Circle 789 on page 19

Ratio Plotter

for laboratory testing purposes

Automatic and continuous ratio plotter saves laboratory testing time, eliminates data reduction, and speeds test evaluation. Unit plots a complete vibration transmissibility curve in strip-chart form during vibration test cycle for immediate evaluation of equipment performance. Unit ratios any parameters that can be indicated by two ac voltages, such as stresses, loads, flow rates, displacements, accelerations and pressures. Range of four full-scale settings permits plotting of ratios from 0-0.2 to

Clean, uniform, exact heat to match the size and shape of your production equipment



CHROMALOX

Electric Strip Heaters

Quickly and easily bolt or clamp Chromalox Electric Strip Heaters to your platens, dies, kettles, tanks, pipes, ovens, air ducts, for the many advantages obtained only with electric heat.

Lengths 4" to 96" Widths ¼" to 2½"
Cross-section curving or lengthwise bending.
Ring Diameters 2½" to 11"
115, 208, 230, 480 Volts 35 to 5,000 Watts
Sheath Materials: rust resisting iron, high temperature chrome steel, Monel
Choice of convenient terminal placements.

FREE BULLETIN

Call your Chromalox Representative . . . or write today for Bulletin F1566.

Edwin L. Wiegand Company
7575 Thomas Boulevard, Pittsburgh 8, Pa.
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CHROMALOX
EDWIN L. WIEGAND COMPANY

Circle 563 on page 19

NEW MINIATURIZED HOWARD MODEL 9200 INDUCTION MOTOR

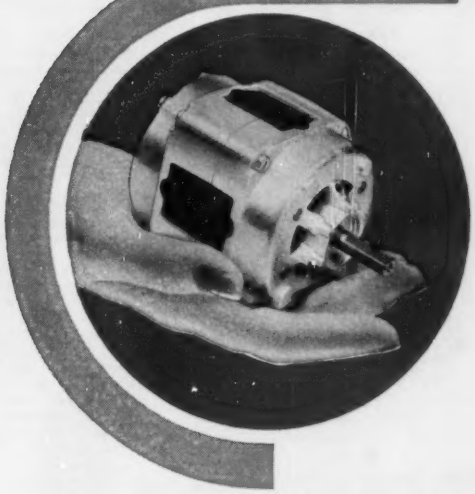
Now available from Howard Industries, Inc. is an exclusive Miniaturized Induction motor with *all* the features of an ultra modern power motor for use in tape recorders, communication equipment, office machines, turn table, movie projectors, air craft, instruments, electronic devices and many more applications.

Special design of magnetic and electrical circuits (24/20 slots), sinusoidally distributed windings, internal rotor slotting combined with unique mechanical features result in exceptionally quiet operation, low level magnetic hum, reduced external magnetic field, low temperature rise, minimum cogging and hunting.

Howard's Model 9200 has been rated by experienced engineers as the finest small induction motor on the market.

Performance ratings of these motors are outstanding, comparable to those of considerably larger frame sizes. For complete details, engineering drawings and samples, write, wire or phone HOWARD today.

unusual power in a small frame size



HOWARD MODEL 9200 Permanent Split Capacitor, Single Phase, 50/60 Cycle Induction, Torque, Synchronous Type—Also available in two or three phase designs.

PERFORMANCE COMPARISON TO CONVENTIONAL MOTOR OF THE SAME OUTPUT RATING

reluctance synchronous single phase permanent capacitor type

	Good Reluctance Motor	Howard SWC-9214 Motor
HP	1/75	1/75
Volt	115	115
C.P.S.	60	60
R.P.M.	1800	1800
Capacitor	2.5 MFD	2.5 MFD
Load Torque	7.5 oz. in.	7.5 oz. in.
Line Amps (input)	.37	.33
Line Watt (input)	36	34
Power Factor	85%	90%
Efficiency	27.7%	29.5%
Temperature Rise °C	36.5°C	26.3°C
Starting Torque	10 oz. in.	11 oz. in.
Pull-in Torque	9 oz. in.	11 oz. in.
Pull-out Torque	9.5 oz. in.	12 oz. in.

CONSTRUCTION SPECIFICATIONS:

General: Open, self ventilated, versatile mount construction. Laminations are stamped from high grade silicon electrical steel. The stator core is housed inside a rigid framework consisting of the two aluminum die cast end brackets telescoped into each other with both rabbets precision machined from bearing bores.

This type of construction eliminates the danger of bending out of shape of the stator structure which is possible in a conventional skeleton type motor.

Bearings: Motors can be supplied with porous bronze sleeve bearings of self aligning or rigid type. An adjustable thrust and end play device is provided with each motor for horizontal, vertical, or thrust loading. With sleeve bearings, large felt oil reservoirs are provided. At request, motors can be supplied with permanently lubricated sealed or shielded ball bearings.

Mountings: Motor frame is designed to permit 6 types of mountings:

Rigid pad or base	Flange mounting
Recessed pad	Extended nut or thru bolt
Resilient ring (small and large size)	Face mounting

Frame Size: 2⅛ x 2⅛ with overall length of 4 1/32 for 9210 frame and 4 13/32 for 9214 frame.

Ratings: Single phase, 115, 50/60 cycle, permanent split capacitor, continuous duty, 40° C. rise and 2 & 3 phase 230 volts, 50 to 60 cycles.

Induction Type:	(RWH 9210 & 9214) 2, 4, 6, & 8 Poles HP Range: 1/300 to 1/30 Hp
Torque Motors:	(RWC 9210 & 0214) 4 & 6 Pole Torque Range: 5 to 12 Inch-Ounce of Stalled Torque Cogging of 6 pole motor + or −2%
Reluctance Synchronous:	(SWC 9210 & 9214) 2 & 4 Pole HP Range 1/250 to 1/50 HP
Hysteresis Synchronous:	(HWC 9210 & 9214) 2, 4, 6, & 8 Pole HP Range: 1/250 to 1/75 HP

HOWARD MOTORS: *Universal & D.C.—1/200 to 1/2 HP, Shaded Pole—1/2000 to 1/8 HP, Induction—1/1400 to 1/4 HP, Servo Motors · Gear Motors · Blowers*

HOWARD

HOWARD INDUSTRIES, INC. 1735 State St., Racine, Wisconsin/Teletype: RAC 344

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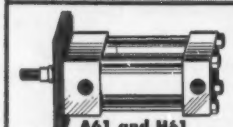
over 8,000 Different Cylinder SELECTIONS—

Miller AIR AND HYDRAULIC CYLINDERS AND BOOSTERS "IN STOCK" for immediate delivery...

See Miller Bulletins A-105K (Air) and H-104K (Hydraulic) for Complete Dimensions and Engineering Data on these "in-stock" sizes and other Custom Miller Cylinders in bores up to 20" and strokes up to 22 feet.

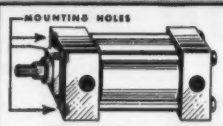
"IN-STOCK" MODELS

"A" Signifies Miller 200 psi Air Cylinders; "H", 2000 psi Hydraulic Cylinders. Interchangeable Mountings Are Shown In Red On Drawings.

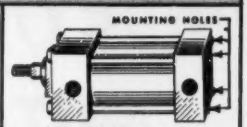


A61 and H61
Flange Mounting on Rod End
(A61 not available in 8" bore)

A62 and H62
Flange Mounting on Cap End
(A62 not available in 8" bore)

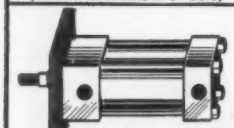


A63—3" Bore only
Flange Mounting on Rod End

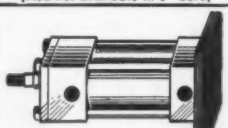


A64—8" Bore only
Flange Mounting on Cap End

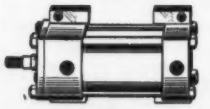
A50 & H50—Tie Rods not extended beyond nuts.
A51 & H51—Tie Rods extended both ends (shown).
A52 & H52—Tie Rods extended. Cap End only.
A53 & H53—Tie Rods Extended. Rod End only.
A54 & H54—Two Tie Rods extended at both ends.



H65—Hydraulic Only
Flange Mounting on Rod End

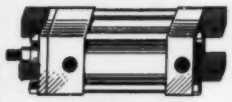


H66—Hydraulic Only
Flange Mounting on Cap End

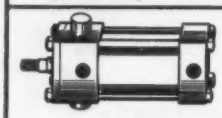


A72 and H72
Side Lug Mounting

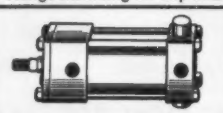
A74 and H74
Side Flush Mounting



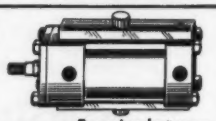
A77 and H77
Side or Foot Mounting



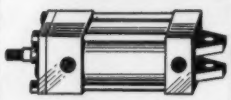
A81 and H81 Trunnion Mounting on Rod End



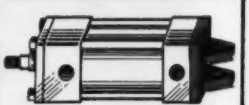
A82 and H82 Trunnion Mounting on Cap End



A83 and H83 Trunnion between Head and Cap (one week delivery)



A84 and H84
Pivot Mounting



A86 and H86
Pivot Mounting

IN STOCK BORES In Inches

"IN-STOCK" STROKES (in Inches)

	Bores	Rod Dia.	Rod Turn Down & Threads																					
AIR	1½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12								
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12								
	2	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	2½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	3¼	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	4	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	5	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	6	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	8	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
HYDRAULIC	1½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12									
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12									
	2	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	2½	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	3¼	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	4	1¾"	1¼-12	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	5	2"	1½-12	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36

(1) (2) (3) (4) refer to the stroke-area notes below.

"A" and "H" Models 82, 84 and 86 with strokes over 18" require stop tubes.

Column strength requires larger diameter piston rods for the following:

Air Cylinder Models A82, 84, and 86 with strokes inside area (1), when operated at 100 psi and over;

All hydraulic models with strokes inside area (2) and Models H82, 84, and 86 with strokes in area (4), when operated at 2000 psi and over;

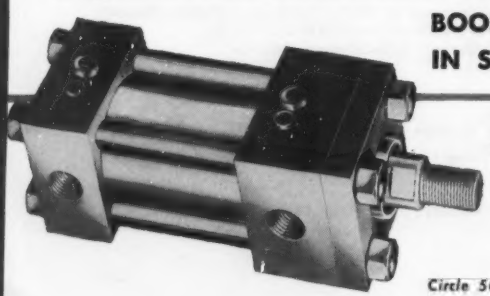
Models H82, 84 and 86 with strokes inside area (3), when operated at 1000 psi and over.

Depending upon Trunnion Pin location, "A" and "H" Models 83 with standard diameter piston rods can have longer strokes than Models 82, 84 and 86.

See Miller File #251 for oversize piston rod and stop tube requirements.

BOOSTERS IN STOCK

Immediate Delivery on the following Miller 25 to 1 Ratio Boosters (80 psi air input produces 2000 psi hydraulic oil output): Model B4, 5" bore, 1" dia. ram, 6" and 12" strokes; Reciprocating Booster Model DA77-RBAB, 5" bore, 1" dia. ram, 6" stroke. Also Booster Tanks, 5" dia., 6" and 10" heights.



Write For Catalog and Stock Price List

Miller

MILLER FLUID POWER DIVISION
FLICK-REEDY CORP.

2006 N. Hawthorne Ave., Melrose Park, Ill.

Circle 565 on page 19

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

0-100. Range for denominator of ratios is 0-20, 0-50, 0-100, 0-200, 0-500 mv and 0-1, 0-2, 0-3, 0-5, and 0-10 v. Frequency response is ±2 percent from 5 to 2000 cps and ±2½ percent from 2000 to 4000 cps. Chart speed is variable from 6 to 960 in. per hour in 16 steps. **Barry Controls Inc.,** Dept. T, 822 Pleasant St., Watertown 72, Mass.

Circle 790 on page 19

Laboratory Furnace

produces heats to 2000 C

Laboratory vacuum furnace is suitable for melting, annealing, brazing, sintering and degassing. Stabilized zirconia crucible, 3 in. ID by 6 in. high, melts 12 lb of steel at up to 2000 C. Substitution of

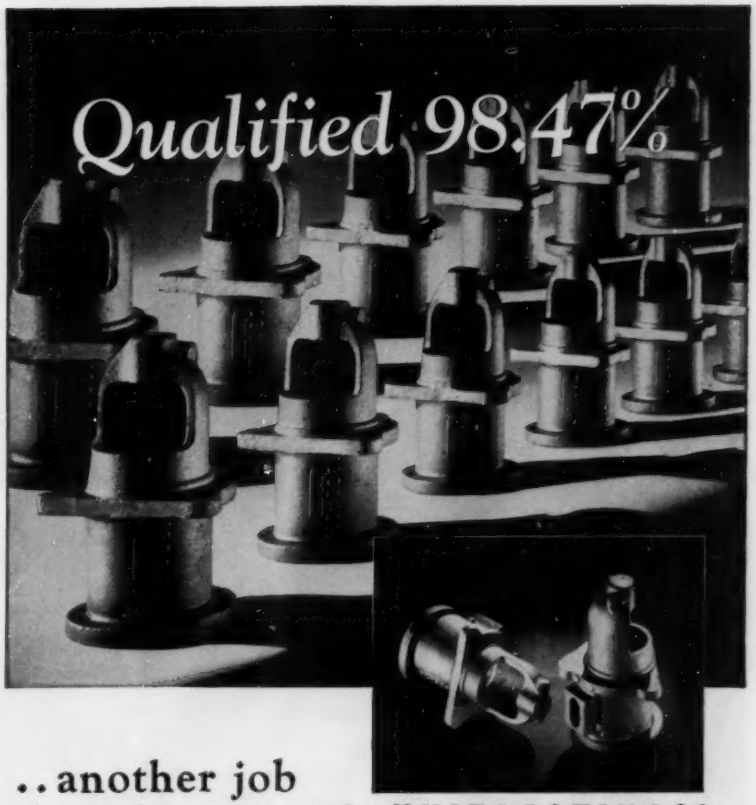
horizontal-type muffle furnace with hot zone of 6 in. ID by 12 or 24 in. long permits processing at temperatures to 1050 C. Vacuum system evacuates chamber to less than 1 x 10^{-5} mm Hg when cold, dry, and out-gassed. **High Vacuum Equipment Corp.,** 2 Churchill Rd., Hingham, Mass.

Circle 791 on page 19

Pressure Transmitter

has large dial for easy reading

Indicating pressure transmitter, accurate to ±½ percent of scale range, is for pneumatic transmission of pressure measurements. Unit measures pressures from 0 to 30 in. of water to 0 to 6000 psi, transmitting a 3 to 15-psi air signal to indicating, recording or controlling instruments. Transmitter has indicating dial with markings readable at distance of 20 ft, eliminating separate field gage. Brack-



..another job done better with *UNITCASTINGS!*

Faced with a problem of economically producing a starter housing that would take more than normal abuse, Unitcast engineers successfully provided the answer with *steel* castings. Previous to the use of Unitcastings, replacement costs were excessive and the need of a tougher material was imperative. Cost was also an important requisite, and by delivering *consistent* quality in conjunction with a tougher material—scrap and lost time has been held at a minimum. To date, more than 33,000 units have qualified with a higher basic cost being offset by practically no replacement and most important —a lower *finished* cost!

Take another look at the *finished* cost of your parts inventory —perhaps you *can do better with Unitcastings!* Consult a Unitcast engineer, soon!

UNITCAST CORPORATION, Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast QUALITY STEEL CASTINGS

Circle 566 on page 19

WHAT'S YOUR CLAMPING PROBLEM?
WITTEK
HAS THE ANSWER
Here is a selection from among the many different types and sizes of hose clamps designed and manufactured by WITTEK. Whatever the hose connecting problem, it's a safe bet that WITTEK (leader for over a quarter century) has the exact type and size clamp to do the job right! Let WITTEK help solve your clamping problems. Write today.
5187
WITTEK MANUFACTURING COMPANY
4349 West 24th Place • Chicago 23, Illinois

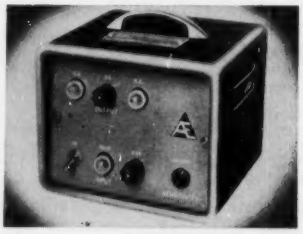
Engineering Equipment

et permits wall or pipe mounting of unit. Size is 8⅛ in. high, 5⅞ in. wide and 4⅛ in. deep; weight is 8 lbs. **Foxboro Co.**, Foxboro, Mass.

Circle 792 on page 19

Miniature Control Unit

ultra-sensitive device controls up to 500 w



Portable, miniature control unit is an ultra-sensitive, heavy-duty electronic switch that will control up to 500 w, either delivered at 115 v ac, 60 cycle, or switched by internal contacts. Minimum input impedance is 2 megohms. Unit can be used with many types of transducers or detector devices, or may be actuated directly by any minute electrical contact. **Autron Engineering Inc.**, 1254 W. Sixth Street, Los Angeles 17, Calif.

Circle 793 on page 19

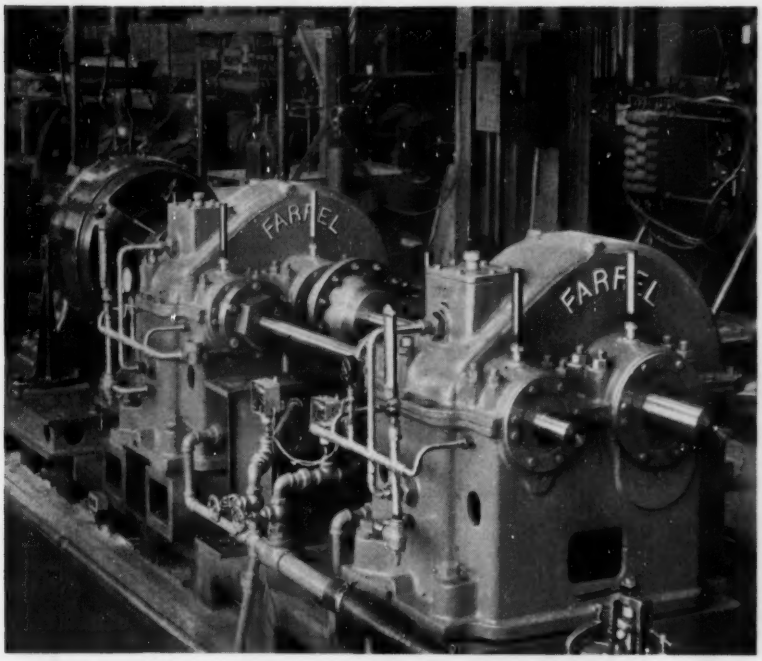
Temperature Control

has fail-safe electrical circuit

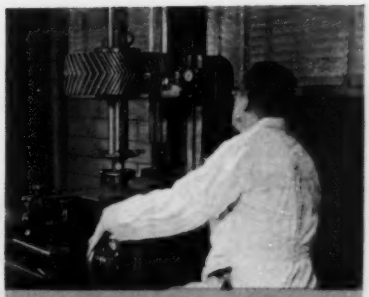
Model HL 15-10 high-temperature limit control is for fast-acting precision control of critical temperatures. Unit cuts off heat when predetermined limit is exceeded. Bulb temperature is indicated on calibrated scale. Snap - acting switch in control circuit is manual-reset type, and circuit cannot be re-established until reset button is pressed. A second switch, normally closed, opens only if temperature drops below lowest expected ambient temperature. This provides a fail-safe feature, as any loss of fill in thermal element will cause a drop in indicated temperature which will actuate the switch and prevent a start-up of the process being controlled. Scale and element ranges available are 0 to 900 F and 0 to 1100 F. **Partlow Corp.**, New Hartford, N. Y.

Circle 794 on page 19

Farrel® speed reducers get a physical checkup

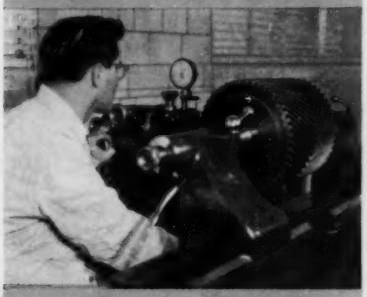


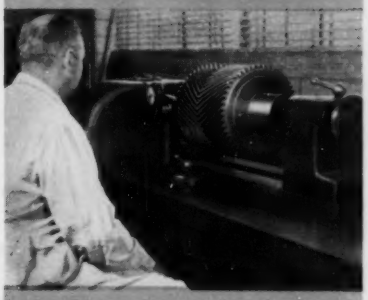
Setup for testing two high-speed units to observe performance under various conditions of load and speed.



▲ Involute tooth checker for measuring accuracy of profile.

▼ Checking accuracy of tooth spacing.





▲ Checking helix angle or lead.

▼ Accuracy and uniformity of tooth thickness is checked with Farrel comparator.

Recently, the Farrel line of speed reducers was re-engineered, rerated and expanded to increase the horsepower in relation to size, and to extend the advantages of the units to additional applications.

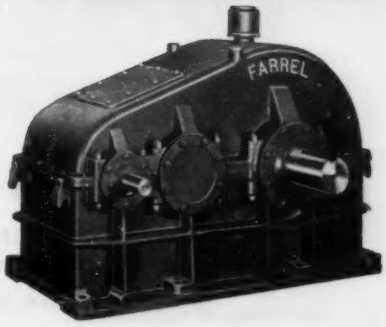
A vital phase of this program was the physical research involved. The many improvements and consistent high quality found in the new line are a result of exhaustive experimentation which was carried on in connection with every aspect of speed reducer manufacture. Pictured here, are some of the facilities and equipment employed in the Farrel laboratory and shops for checking and testing gear units.

Toughness... stamina... long life ... these are the qualities of Farrel units which stem from the sound design, the high-grade materials, and the step-by-step precision that go into their making. Investigate the broad new line of Farrel speed reducers. For further details, send for a copy of Bulletin 450.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
Sales Offices: Ansonia, Buffalo, Boston, Akron, Ann Arbor (Mich.), Chicago, Minneapolis, Fayetteville (N. C.), Los Angeles, Salt Lake City, Tulsa, Houston

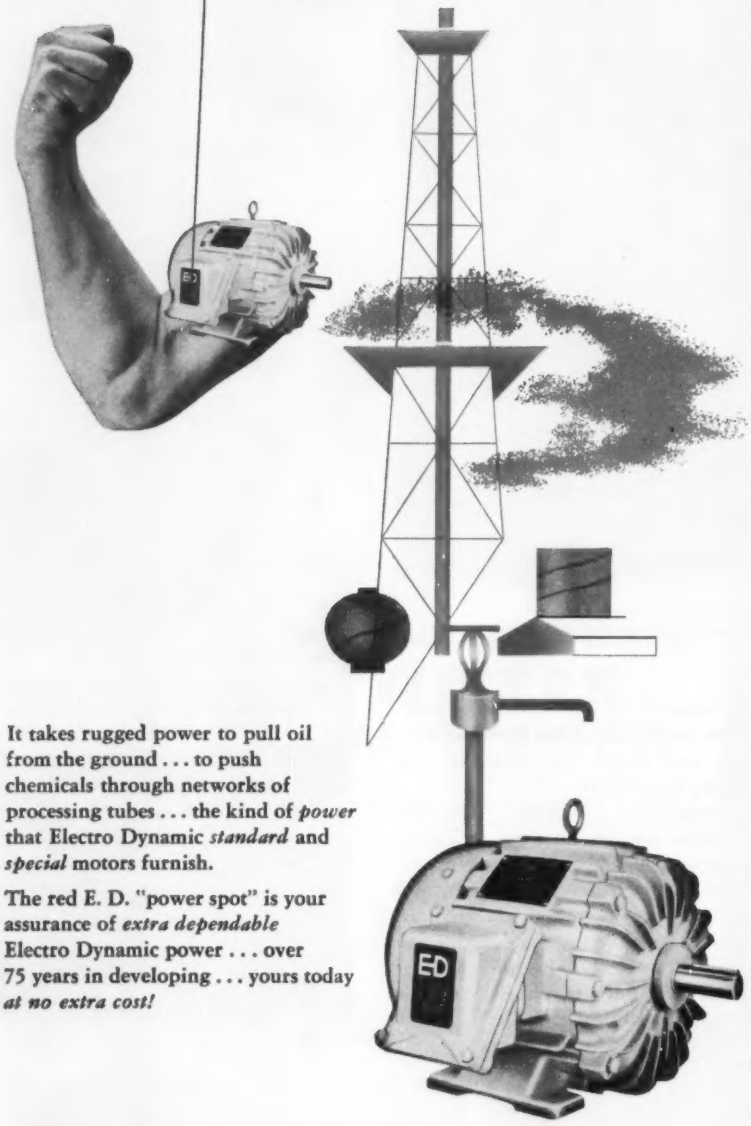
Farrel-Birmingham®



FB-1116

The mark of an Extra Dependable machine

POWER
for the
oil and chemical
industries



It takes rugged power to pull oil from the ground . . . to push chemicals through networks of processing tubes . . . the kind of *power* that Electro Dynamic *standard* and *special* motors furnish.

The red E. D. "power spot" is your assurance of *extra dependable* Electro Dynamic power . . . over 75 years in developing . . . yours today *at no extra cost!*

ELECTRO DYNAMIC
DIVISION OF GENERAL DYNAMICS
CORPORATION
BAYONNE, NEW JERSEY

Stress Relief

ENGINEERS are a breed apart —by their own definition or as seen through the eyes of someone else. A librarian, for example, has ample opportunity to observe many specimens and to classify them.

Dr. Margaret Holtman, librarian for P. R. Mallory & Co. Inc., Indianapolis, and artist Stan Hasse have collaborated in the preparation of this report on the engineering species:

The Library Zoo

Mr. Biblio Maniac

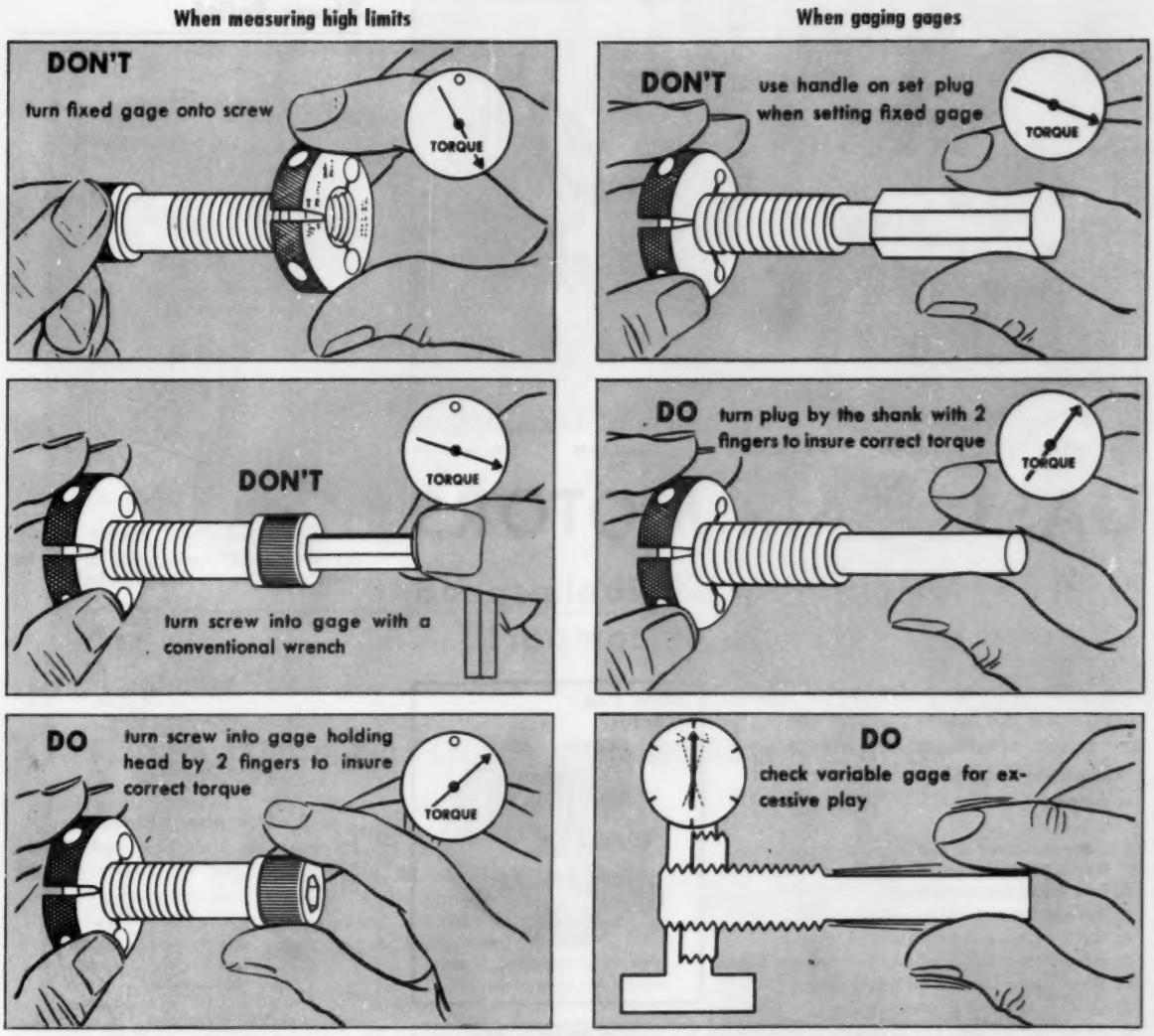
The hoarder; he keeps everything on or in his desk. (Try to get it back.)

Mr. O. U. Gremlin

I returned those reports. Why don't you keep your records straight! (He finds them a year later.)

Mr. Scatta Brane

Where, oh where, did I put them? I believe I returned them; didn't I? (He reloans catalogs, books, etc., and doesn't remember to whom he loaned them.)



These illustrations from new SPS booklet show some of the do's and don'ts of gaging precision threads.

3A threads: what they are; how to gage them — new SPS booklet tells all

Threads made to Class 3A fit are the most precise in general use in industry. But you do not always get the 3A precision you specify. Because of many different gaging techniques that yield varying results, screws with threads well outside the Class 3A tolerance limits often pass inspection.

SPS has prepared a new booklet on this subject. It explains clearly what Class 3A threads are and the pros and cons involved in the widely varying gaging techniques in use today. It reviews the gaging of high and low limits of 3A threads, sampling techniques, and even the methods of gaging gages.

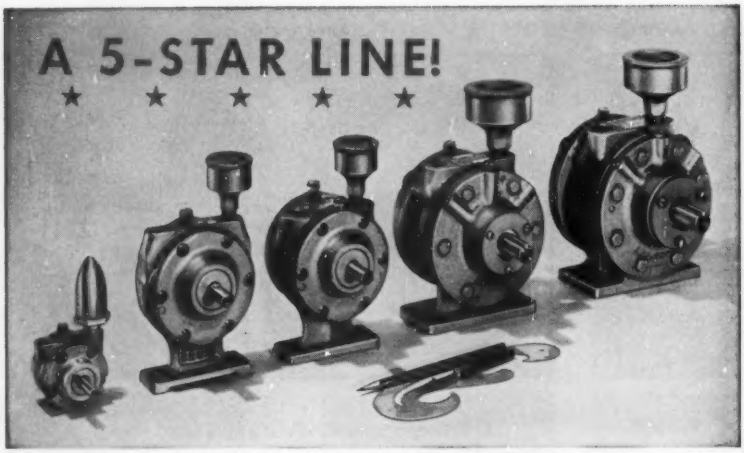
All standard UNBRAKO socket screw products fall within specified tolerance limits *no matter what method is used to gage them.* Leading industrial distributors carry complete stocks. Unbrako Socket Screw Division, STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.

Form 2239, "Class 3A Threads: what they are; how to gage them." 16 pages, with many illustrations. Write for free copy today.

STANDARD PRESSED STEEL CO.

UNBRAKO® SOCKET SCREW DIVISION SPS

JENKINTOWN PENNSYLVANIA



★ Model 1AM ★ Model 2AM ★ Model 4AM ★ Model 6AM ★ Model 8AM

GAST rotary vane AIR MOTORS

offer explosion-proof, variable-speed power that's surprisingly compact!

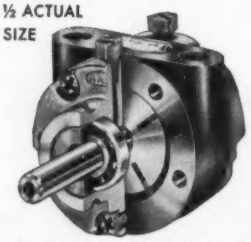
Here's the complete 5-star line of Gast rotary-vane Air Motors . . . offering ten unique advantages on products or applications located near a compressed air source:

1. Explosion-proof power in explosive or inflammable atmospheres. No sparks, no danger!
2. Low initial cost compared to other motors.
3. Variable in speed with simple valve control.
4. Can't burn out if overloaded or stalled.
5. Reversible rotation optional on 4AM and 8AM.
6. Rotor vanes take up their own wear.
7. Quickly attached to plant air lines.
8. Amazingly compact and light for h.p. delivered.
9. Ball-bearing; almost service-free design.
10. Mechanically simple, neat in appearance.

As original equipment, Gast Air Motors are driving pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, thread spooling machines and many other products. Right or left rotation available. Housings available with or without foot on most models.

GAST MANUFACTURING CORP.,
P. O. Box 117-P, Benton Harbor, Mich.

MODEL 1 AM
½ ACTUAL SIZE



Note the simple principle and trouble-free construction.

PERFORMANCE TABLE

Model No.	R.P.M.	HORSE POWER at 60 P.S.I.	HORSE POWER at 90 P.S.I.	Wt. Lbs.
1 AM	2,000 5,000	0.11 0.21	0.13 0.30	1½
2 AM	1,000 2,000	0.22 0.40	0.35 0.57	5¼
4 AM	1,000 2,000	0.48 0.78	0.73 1.10	7½
6 AM	500 2,000	0.40 1.30	0.65 2.00	18
8 AM	500 1,500	1.00 2.30	1.45 3.80	25

For complete performance data, write for Bulletins! Specify models that interest you.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

Stress Relief

Mr. Gene E. Yuss
I dunno where they are. Don't bother me. (He's in a fog.)

Mr. Rip van Winkle
He waits until closing time to ask for literature, after the library is locked.

Prof. Absent Minded
He wants the little blue book he borrowed a year ago, but he doesn't remember the title.

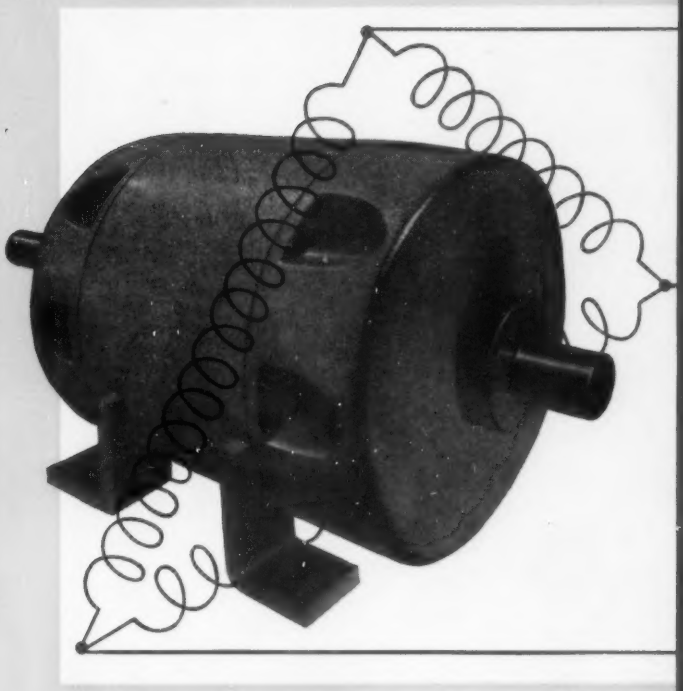
Mr. Undee Cided
He doesn't know what he is looking for, but it is on the shelf somewhere.

Mr. Eger Beaver
Did my book come in yet? (On the hour, every hour.)

Mr. Ima Gointo
Yes, I'll bring the book back tomorrow. (Tomorrow never comes.)

Circle 571 on page 19

Circle 572 on page 19→



SIMPLE DEPENDABLE protection against phase failure and phase reversal

A-B protector

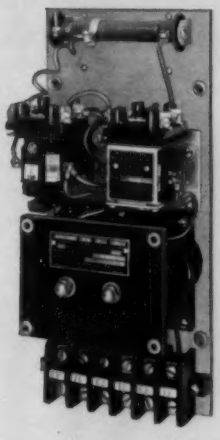
opens control circuit in 3 to 4 cycles...under all load conditions

When men, motors, or the driven machines can be "hurt" by "phase failure" or "phase reversal" . . . the new Allen-Bradley Bulletin 812 should be used as a low cost and reliable "safety" insurance. It detects phase failures and reversals electrically, and within not more than 3 or 4 cycles, opens the motor control circuit—regardless of motor load (including no load)—and thus stops the motor.

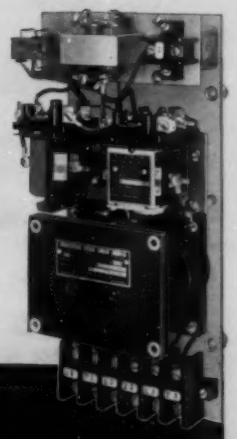
The Bulletin 812 Type A relay protects motors against all phase failures. The Type B relay protects motors against loss of a phase and reversed phase rotation. For the first time, dependable protection is provided for motors supplied by Wye-Delta and Delta-Wye power systems having the neutral ungrounded or not connected to the circuit.

Bulletin 812 relays offer positive protection against motor or machine damage due to opening a primary line—and under all "load" conditions. No field adjustment is required. Remote reset is inherent. Furthermore, as a static device which does not rely for its operation on "motor" revolution the possibility of failure to operate is eliminated.

Bulletin 812 relays are built in four sizes which will reliably protect motors with full load currents from 1.25 amperes to 300 amperes. Let us send you more information about this dependable answer to phase failure and phase reversal problems.



Bulletin 812 Type A phase failure relay protects a 3-phase motor against loss of a phase.



Bulletin 812 Type B phase failure and phase reversal relay protects a 3-phase motor against both loss of a phase and phase reversal.

ALLEN-BRADLEY
QUALITY
MOTOR CONTROL

A-B Quality

Allen-Bradley Co.
1316 S. Second St.
Milwaukee 4, Wis.

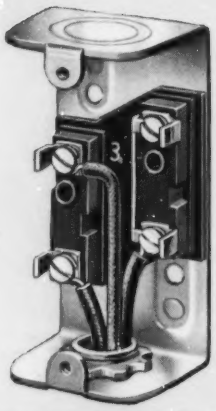
In Canada—
Allen-Bradley Canada Ltd.
Galt, Ontario

4-57-MR

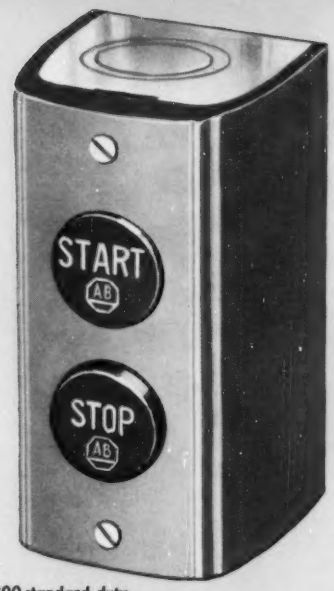
new Allen-Bradley Bulletin 800 Standard-duty Push Buttons

CAN BE WIRED IN HALF THE TIME!

CONTACT MECHANISM IN THE COVER—COMPLETELY PROTECTED FROM CARELESS SCREWDRIVERS AND CARELESS WIRING.



WIRING TERMINALS IN THE BASE —COMPLETELY EXPOSED FOR EASY WIRING.



Here's an entirely new idea in push button stations—a wrap-around cover which contains and protects the contact mechanism. Removing the cover exposes all terminals for instant and easy wiring. Heavy, silver plated contacts connect the push button assembly in the cover with the terminals in the base.

Matching ribs in the cover and notches in the molded terminal base eliminate the possibility of having wiring connections made incorrectly. A molded, bakelite shield protects the contact mechanism and prevents careless wiring from interfering with contact operation. All push button contacts are silver and of the double break construction.

Specify the new Allen-Bradley standard-duty station on your next order. Its installation time-saving feature, alone, should make you a regular customer!

Bulletin 800 standard-duty push buttons—with strong, gray, molded cover are "good-looking" and "safe" in operation. All stations have dual knockouts, top and bottom.

4-57-MR

SELECTOR SWITCH

You can't beat this for convenience—a selector switch with the same easy-to-wire construction as the push buttons, shown above—plus the feature that you can change—*in seconds*—from two position to three position (or vice versa)! The correct name plate is furnished with each switch. See for yourself how easily this is accomplished.

CHANGE IT FROM 2 POSITION TO 3 POSITION (or vice versa)...in 30 Seconds!

A-B Quality

ALLEN-BRADLEY

QUALITY

MOTOR CONTROL

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ontario

Stress Relief

Mr. Unsoph Isticated

Indexes aren't necessary. Let 'em root for it! What did they do before they had a library?

Mr. Indig Nashun

Yes, I returned them! I keep a record of it!

Captain M. E. Doitt

(Of the Swiss Navy Project.) He repairs TV's on the side. He also has an amateur radio station. (He takes up your time for you know what.)

Mr. Super Duper Snooper

He comes in the library at noontime and messes up the stacks you have ready for routing.

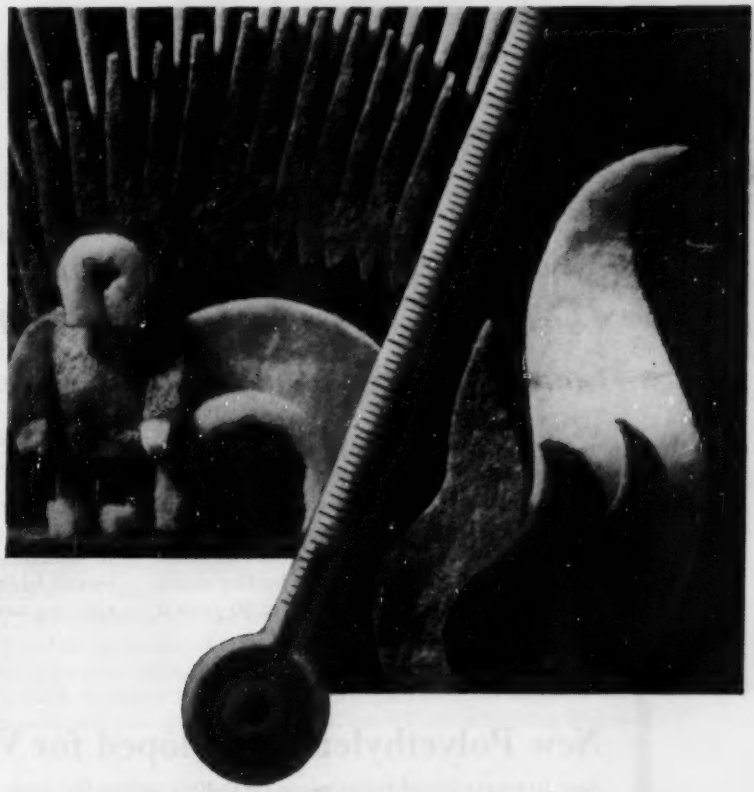
Mr. Cy Clone

He is in a hurry, he can't wait. He wants reports before they are published.

Mr. Model Patron

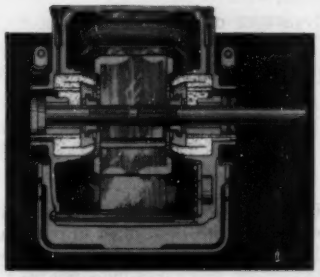
Journals? I never keep them. I always return them. (Oh?)

(*Concluded on Page* 268)



Felt Stands the Gaff

...FROM −80°F TO 250°F



FELT IN USE . . . Small motors use felt washers, rectangles, odd shapes and wicks in many places to increase reliability, like on this Redmond Micromotor shown here. Felt wicking and pourous bronze bushings provide positive lubrication for long, heavy-duty operation in any position. Felt seals also keep dirt and dust out of vital areas.

Felt by Felters has what it takes when operating conditions are extreme.

Stands over 30 days at 250°F of dry heat without materially weakening its structure. Same at −60°F as at normal 74°F and at −80°F its properties are only slightly different. Even when exposed to greater extremes, felt will always resume its natural feel.

Send for Design Book

Complete technical data has been prepared for your use in selecting and specifying the *right* felt for the job your product has to do. Send for it today. The Felters Company, 220 South St., Boston 11, Mass.

Get the Best, Specify

FELT by FELTERS

Manufacturers of Felt and Felt Products — *Representatives in All Principal Cities*

Designing with BAKELITE Plastics

- *New material for vacuum-forming*
- *Electric shaver's comb framed in plastic*
- *Coating improves appearance, saves in production*

When you're working on a new design idea, find out if there's a plastic ready and waiting to help do a better job. A BAKELITE plastic can often extend the range of your ideas—help get a jump on competition—because there's something new in plastics just about every day.

In plastics, Bakelite Company is your leading source of information, as well as of materials. For 46 years it has been a leader in the field, offering the widest variety and number of plastics and resins. You can choose from BAKELITE Brand Phenolics, Vinyls, Styrenes, Polyesters, Polyethylenes, Epoxies, Silicones, and Impact Styrenes. In addition, Bakelite Company offers the aid of its extensive laboratory facilities and technical resources in applying modern plastics to your problems.

1 New Polyethylene Developed for Vacuum-Forming

New BAKELITE Brand Polyethylene DFD-4030 permits the application of polyethylene to the economical process of vacuum or thermo-forming—a development of major importance.

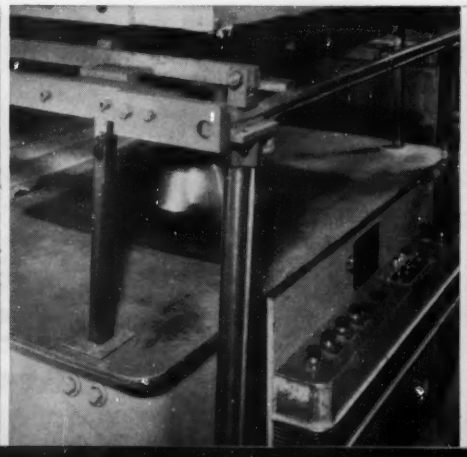
The first of its kind, DFD-4030 has been specifically compounded for sheet extrusion and vacuum-forming. This material provides ease of fabrication, bright color possibilities, light weight, and chemical resistance, together with the economy of vacuum-forming. Products made from it possess an attractive appearance, characterized by high gloss, complete freedom from skinning, and improved stress cracking resistance due to a high molecular weight. Colorants are completely dispersed, with no streaking.

Designers can apply the advantages of production economy, deep draws, and eye-appeal to a wide variety of products, including housewares and packaging items. Some typical properties of the new compound are shown in the adjoining table. You can get more information by writing to Dept. WP103 for KABELITEMS No. 7.

Specific Gravity (D792-50 Method A)	0.92
Melt Index (D1238-52T)	1.7-2.4
Tensile Strength (D412-51T) psi	1800
Per Cent Elongation (D412-51T)	550
Brittle Temperature (D746-55T), 80% non-failure, deg. C.	—80
Stiffness Modulus (Torsion) at 23 deg. C. (D1043-51)	22,000
Durometer Hardness (D676-49T)	40 at 75 deg. F. 28 at 140 deg. F.
Coloring Properties	Unlimited

High gloss is evident on this polyethylene sheet being placed in clamping frame just prior to vacuum-forming.

Heater drawn forward over polyethylene sheet with bowl mold in position. Low mold cost is an important advantage of the vacuum-forming process.

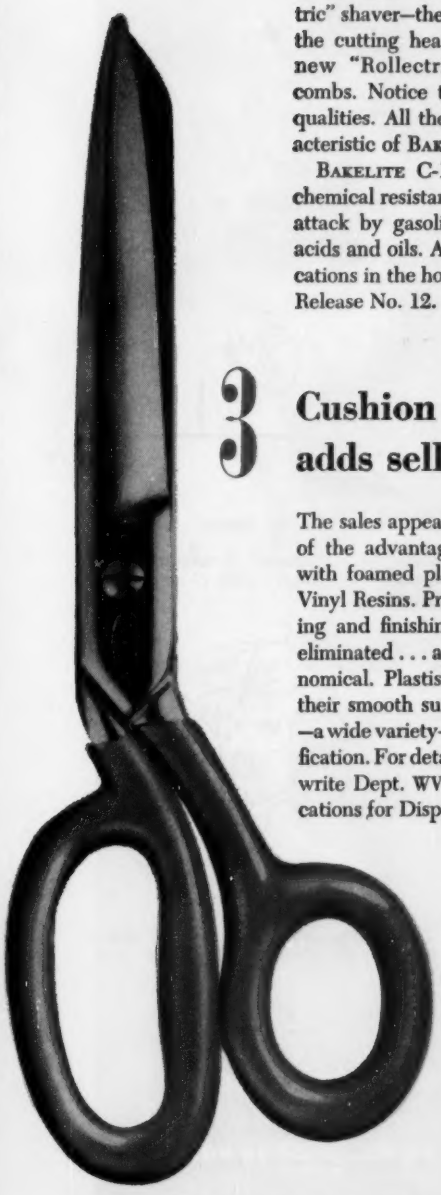


Heated polyethylene sheet drapes over mold before vacuum is applied. DFD-4030 is readily deep-drawn to large-size sections.

2 C-11 Plastic crowns the newest "Remington"

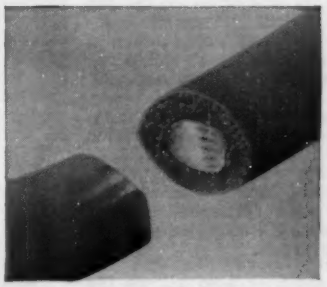
Take a look at the upper section of the new Remington "Rollectric" shaver—the part that houses the cutting head and holds the new "Rollectric" steel roller combs. Notice the even color and fine finish. Strength without bulk is another of its qualities. All these features—strength, finish, color, and good molding details—are characteristic of BAKELITE C-11 Plastic.

BAKELITE C-11, an acrylonitrile-styrene copolymer, is also notable for its superior chemical resistance. In this application, it is unaffected by perspiration. It also withstands attack by gasoline, turpentine, detergents, ink, coffee, carbon tetrachloride, and food acids and oils. As a result, BAKELITE C-11 Plastic is being used for more and more applications in the housewares and packaging fields. Write Dept. WT-103 for Molding Technical Release No. 12.



3 Cushion coating on handles saves finishing, adds selling point

The sales appeal of color and comfort are just part of the advantages resulting from handles coated with foamed plastisols based on BAKELITE Brand Vinyl Resins. Production benefits too. Hand polishing and finishing of rough castings can often be eliminated . . . applying the coating is fast and economical. Plastisols resist moisture and acids, and their smooth surface is virtually dirt-proof. Colors —a wide variety—stay true, permit easy visual identification. For detailed information on these materials, write Dept. WV-103 and ask for "Industrial Applications for Dispersions of Vinyl Resins."



Cross section shows relative thickness of resilient coating that provides a smooth, comfortable grip for scissors handles and conforms to uneven under-surface.

There's more to design with in

PHENOLICS
STYRENES
IMPACT STYRENES
POLYETHYLENES
VINYLS
EPOXIES
POLYESTERS
SILICONES

BAKELITE BRAND **PLASTICS**

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC.

Circle 574 on page 19

(Advertisement)

ADVANTAGES OF FLEXIBLE SHAFTING

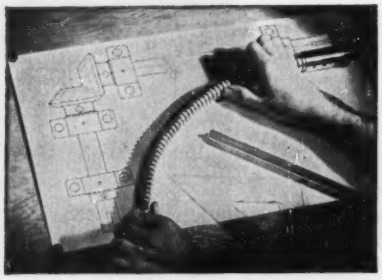
For Power Drive and Remote Control

by

C. Hotchkiss, Jr.

Application Engineer

Stow Manufacturing Company



Flexible shafting has the following advantages over other type drives:

1—it is often the simplest method of transmitting power between two points which are not collinear or which have relative motion

2—eliminates exposed revolving parts

3—does not require accurate alignment

4—easy to install and maintain

Relative Motion — Where two shafts which have relative motion must be connected, flexible shafting is often the ideal means of transmission. In many cases it eliminates a much more complicated drive which would, necessarily, include telescopic joints; further, it eliminates the danger of exposed moving parts. See figure 2, which shows a ¾-inch Stow flexible shaft driving an Avery Rake built by the Minneapolis Moline Co.

Not Collinear—Where it is necessary to connect two shafts which are not collinear, a simple arrangement of a single belt or two universal joints will often do the job adequately. But, in many cases where the path of transmission is more complicated and would require a more expensive arrangement of mechanical components, flexible shafting provides a simple, low cost, efficient drive which is easy to install because it does not require accurate alignment. See example, figure 1, in which a 1¼-inch Stow flexible shaft is used to drive the auger on a G.L.F. bulk feed truck.

Flexible shafting also allows the designer greater freedom in locating either the drive or the driven component on a piece of equipment.

Fig. 1

Fig. 2

Other typical applications of this type are used on portable power tools when motors are too heavy to be mounted on the tool—such as portable grinders, sanders, paint scrapers, saws and tree tappers. And, since flexible shafting is not affected by vibration, it is an ideal drive for applications where a high degree of vibration is involved—such as in vibration testing tables and concrete vibrators.

Stow flexible shafts are available: for power drive applications in diameter sizes from ⅛-inch to 1¼-inches; for remote control applications in diameter sizes from ⅛-inch to 1⅝-inches. The 1¼-inch power drive shaft will transmit up to 10 HP while the 1⅝-inch remote control shaft will transmit up to 4000 lb. in.

For complete engineering data on flexible shafting, including selection charts, write for engineering bulletin 570.

STOW MANUFACTURING COMPANY

11 SHEAR STREET • BINGHAMTON, NEW YORK

Stress Relief

(*Concluded from Page 265*)

Mr. Ozo Important

My work comes first! Send me everything FIRST!

Mr. Earl E. Burd

Before you get your coat off, he wants you to stop and find something for him.

Mr. Al Literat

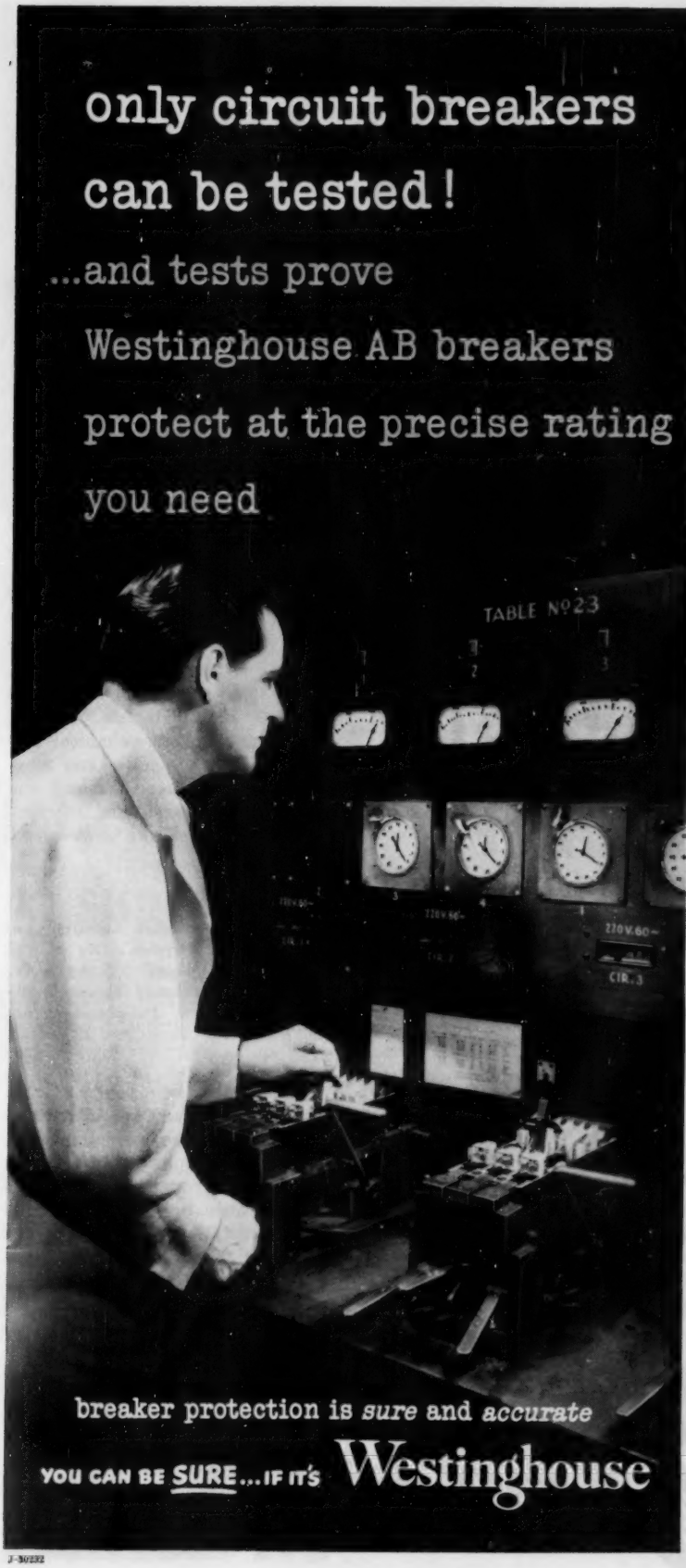
Magazines? Reports? I never read 'em. I don't have time. (He likes guessing games.)

Mrs. Anthony

The librarian, after eight hours of searching for the answers to a jillion problems.

The End

Oh where, oh where has my little book gone,
Oh where, oh where can it be?
Its title is short, but its subject is long,
Oh where, oh where can it be???



PRE-TESTED CIRCUIT PROTECTION IS "INSURANCE"

by H. D. Dorfman
Westinghouse Electric Corporation

A most important consideration in selecting a circuit protective device is its ability to protect at the precise rating for which it is designed. Under-rated devices are nearly as bad, though not as hazardous, as over-rated ones. Load testing is the only positive way to be sure a circuit is truly protected.

Obviously, fuses cannot be calibrated and load-tested. An operation-tested fuse is like a tested match, of no further use. Thus, precision protection may not be assured.

Circuit breaker accuracy can be tested by the manufacturer before shipping and retested, if desired, in the field. When tested breakers are provided by a reputable company, you can be sure they will protect at exactly the rated load.

Heat-Treating Important

A number of factors distinguish the properly designed and tested breaker. Life-long maintenance of calibration is assured by several preliminary steps. Heat-treating of bimetal subassemblies relieves any stresses set up during manufacture and insures their permanent "set." Failure to heat-treat can result in later destruction of calibration by load cycles.

Latching surfaces should be ground and polished to eliminate erratic tripping. Latch members also should be heat-treated to prevent wear and distortion. To insure perfect mating of parts, the production and assembly of circuit breakers should take place in a temperature and humidity-controlled area.

Tests Verify Calibration

These tests conducted on all Type F breakers made by my company, for instance, typify the painstaking care necessary to assure the protective quality of such devices.

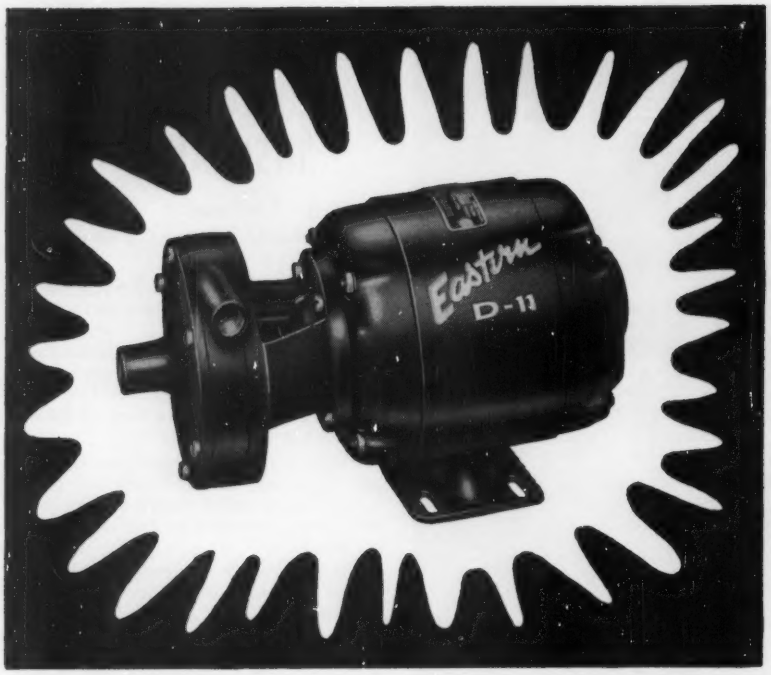
1. Magnetic elements are adjusted to trip at ten times the thermal rating.

2. After pre-setting of calibrating screw, thermal elements are tested to trip the breaker at a specific overload, within strict limits.

3. Only after the second successful thermal tripping run is the cover assembled on the breaker.

4. Following a 5,000-volt insulation check, the thermal calibration is again test-verified to determine that bimetal calibrations were not altered before or during breaker cover placement.

Such tests assure positive circuit protection at the precise rating for which the circuit breaker is designed.



24,830 successful installations!

EASTERN D-11 CENTRIFUGAL PUMP

Why is the D-11 so successful among original equipment manufacturers? *Size and weight* make it ideal. The D-11 is the smallest, close-coupled, single-stage centrifugal pump available with an induction type motor. Eighteen pounds of compact design (9¾" x 4⅝") make it excel in industrial and process equipment, as well as laboratory service, and pilot plant operations.

SPECIAL METALS

A full selection of metals make the D-11 and other Eastern Centrifugal Pumps versatile performers. Available in 18-8 Type 303 and Type 316 Stainless Steel, Monel, Hastelloy "C", Cast Iron and Bronze, Eastern Pumps range from ⅛th to ¾ H.P. with capacities up to 70 G.P.M., pressures to 65 P.S.I.

For complete specifications on all Eastern Centrifugal Pumps, request Bulletin 120-G

Eastern INDUSTRIES, INC.
100 Skiff St., Hamden 14, Conn.

THE ENGINEER'S Library

Recent Books

Mechanical Design for Electronics Production. *By John M. Carroll;* 348 *pages,* 6 *by* 9 *in., clothbound; published by McGraw-Hill Book Co. Inc.,* 330 *West* 42*nd St., New York* 36, *N. Y.; available from* MACHINE DESIGN, $6.50 *postpaid.*

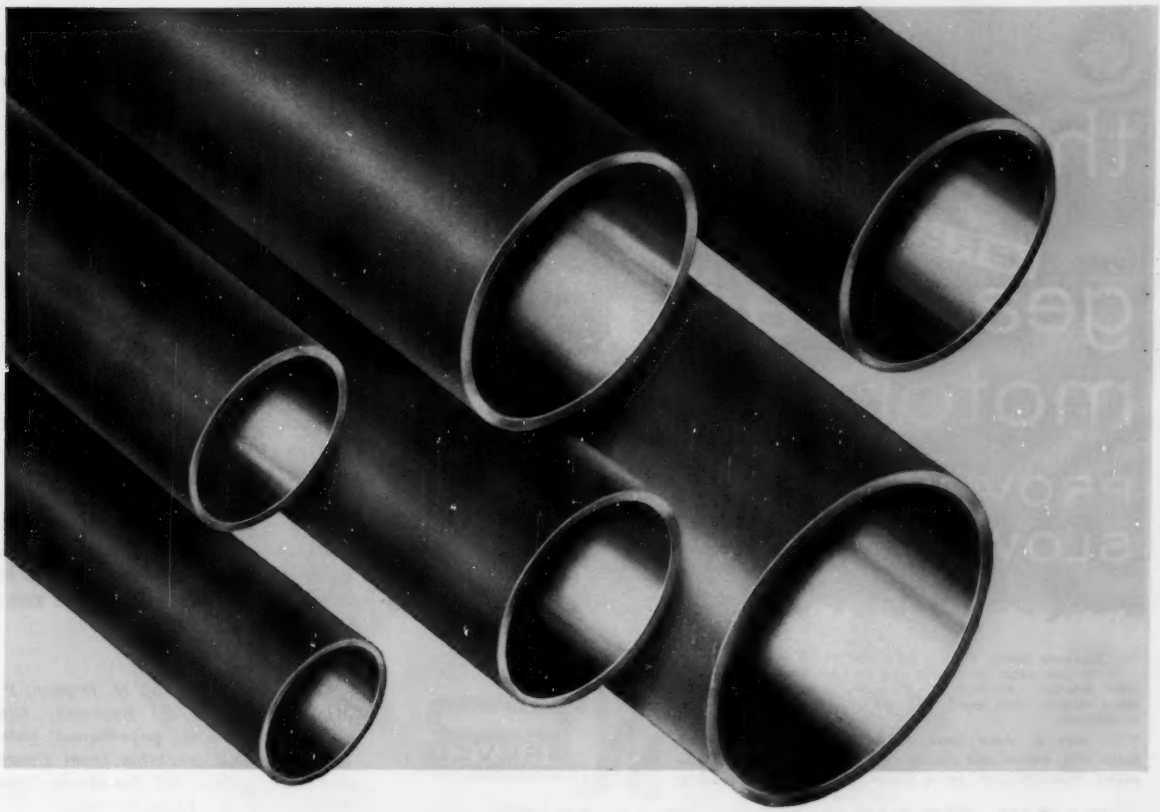
This book presents information concerning special problems of designing and manufacturing devices using electron tubes and transistors. The treatment gives the translation of an aggregation of breadboard circuits into an item of finished equipment suitable for lowest possible manufacturing cost. It contains information concerning processes and materials including sheet-metal work, mechanical layout, machining, electric and magnetic shielding, use of resins and other sealing compounds, mechanisms, electric motors and acceptance tests.

Partial Differential Equations of Mathematical Physics. *By A. G. Webster;* 447 *pages,* 5½ *by* 8 *in., paperbound; published by and available from Dover Publications Inc.,* 920 *Broadway, New York* 10, *N. Y.;* $1.98 *per copy.*

This well-known book, now in its second revised paperbound edition, covers the basic method, theory, and application of partial differential equations. Chapters include deduction of differential equations; wave equations; vibrations; normal functions; Fourier's series and integral; Cauchy's method; potentials; method of Riemann-Volterra; spherical, cylindrical and ellipsoidal harmonics; and the theory of integral equations.

Materials and Processes in Manufacturing. *By E. Paul Degarmo, professor of industrial engineering, University of California;* 755 *pages,* 6 *by* 9 *in., clothbound; published by*

Circle 577 on page 19



J&L cold drawn ELECTRICWELD tubing with a superior SPECIAL SMOOTH I.D. finish

Cold drawn ELECTRICWELD tubing with the superior smooth I.D. finish will cut your production costs in applications like these:

- **cylinder tubing**
- **hydraulic and pressure tubing**
- **shock absorbers**
- **ordnance components**

This new drawn-over-mandrel grade tubing with its mirror-like surface finish helps reduce or eliminate costly machining on many applications. For example, it may be used, without inside honing, for many cylinders through which plungers are passed.

ELECTRICWELD tubing withstands high internal hydrostatic pressures; carries heavy torsion loads; resists high-frequency vibration. It offers a favorable weight-to-strength ratio where loading occurs in all directions.

It is furnished in OD sizes from ½ inch to 2⅞ inches and in wall thickness from 20 to 10 gauge, 0.035 and 0.134 inch. Send coupon today for complete information.

Jones & Laughlin Steel Corporation
Dept. 410, 3 Gateway Center
Pittsburgh 30, Pennsylvania

Send me a copy of your cold drawn ELECTRICWELD tubing booklet.

Name_____

Title_____

Company_____

Address_____

City_____ Zone___ State____

J&L STEEL

Jones & Laughlin

... a great name in steel

this new BREVEL gear-head motor

PROVIDES LOW-COST SLOW MOTION

This gear-head motor, like all Brevel motors, is volume produced . . . to your exact specifications—or you can order from a wide stock selection. Modifications are easily made to meet desired speed, rotation, shaft length, and type of application (continuous or intermittent).

Write, wire or phone today, for informative bulletin MD-104. Better still, outline your problem or send us your specifications—

BREVEL PRODUCTS CORP., 601 W. 26th St., New York 1 · WA 4-4737

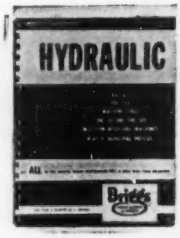
BREVEL

SLOW MOTION IS OUR BUSINESS!

Circle 579 on page 19

BRIGGS OFFERS YOU, FREE, A 12 PAGE MANUAL ON HYDRAULIC FLUID CIRCUITS AND HYDRAULIC OIL FILTRATION

HERE is a big 8½" x 11", file size, 12 page, fully illustrated booklet. It's brimful of technical data and drawings that every designer and engineer will want to read or keep for ready reference. Write for your copy. No obligation.



Briggs — PIONEERS IN MODERN OIL FILTRATION

HYDRAULIC OIL FILTERS

MAIL COUPON NOW

THE BRIGGS FILTRATION COMPANY
DEPT. 144—WASHINGTON 16, D. C.

YES! AT NO COST or obligation, send me the above booklet.

Name .....

Company .....

Address .....

Library

The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from MACHINE DESIGN, $8.50 *postpaid.*

This book discusses basic engineering materials and manufacturing processes: the design opportunities provided, limitations imposed, and translation of ideas into reality through the methods available. The materials section deals primarily with the selection of materials for specific applications and how they react to the various processes. The methods section covers casting and forming, machining, welding, and other manufacturing processes and techniques. In each chapter of the methods section, the emphasis is upon what can be done, how it is done, and the limitations and relative economies involved.

Hydrodynamics. *By H. Dryden, F. Murnaghan and H. Bateman; 634 pages, 5½ by 8 in., paperbound; published by and available from Dover Publications Inc., 920 Broadway, New York 10, N. Y.; $2.50 per copy.*

First published by the National Research Council of the National Council of Scientists, this volume offers a complete coverage of classical hydrodynamics. The data concerns basic fundamentals that do not become obsolete. The book is divided into four divisions: physics of fluids and classical hydrodynamics, motion of an incompressibly viscous fluid, turbulent flow, and compressible fluids. The book has a 3000-item bibliography.

Electronic Computers: Principles and Applications. *Edited by T. E. Ivall; 175 pages 5½ by 8½ in., clothbound; published by Philosophical Library Inc., 15 East 40th St., New York 16, N. Y.; available from* MACHINE DESIGN, $10.00 *postpaid.*

This book is a nonmathematical introduction to the principles and applications of computers employing valves and other electronic devices. The treatment is general in nature in order to give a broad background picture of the whole field of computing. Both digital and analog computers are covered and comparisons are made between the two types. The bulk of the book is devoted to describing their circuitry

Centrifugal Castings for Industry

Does your **Cylindrical** *problem call for a* **Centrifugal** *solution?*

If your product plans call for hollow cylindrical parts, give some thought to these facts. Manufacturers who had never seriously considered cast parts before are discovering important advantages in Sandusky centrifugal castings.

They're getting exceptional resistance to heat, corrosion, abrasion and stress, through the use of special alloys cast centrifugally . . . in diameters from 7" to 54", and lengths to 33 feet depending on diameter . . . and specially machined to specifications.

How can our versatile staff and facilities help you? Tell us your product requirements. Let us explore your ideas. Perhaps we can help solve your cylindrical problems through the vast foundry experience, metallurgical research and machining skills our 46 years offer.

Your request will bring more information promptly . . . or, if you prefer, a personal call by one of our engineers. Sandusky Foundry and Machine Company—Sandusky, Ohio.

Sandusky centrifugal castings offer you 4 important advantages:

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4. ***JOB-READY FINISHED CASTINGS***—reach you machined exactly to your specifications . . . eliminating extra costs from rejects, down-time, loss of production, etc.

Sandusky Centrifugal Castings

Stainless steels—plain carbon and low alloy steels—wide variety of copper base compositions

Circle 581 on page 19

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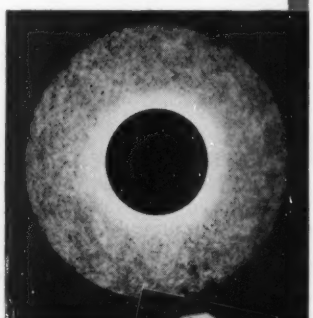

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Filtration Engineers in Principal Cities

Library

and construction. The rapidly developing applications are also outlined.

Scientific Uses of Earth Satellites. *By James A. Van Allen, chairman, Department of Physics, State University of Iowa;* 316 *pages,* 7 *by* 10 *in., clothbound; published by University of Michigan Press, Ann Arbor, Mich; available from* MACHINE DESIGN, $10.00 *postpaid.*

In January, 1956, the Upper Atmosphere Rocket Research Panel held its tenth anniversary meeting, devoted exclusively to specific detailed proposals for the scientific use of small artificial satellites of the earth. This book is a compilation of 33 of the papers presented there. Among the problems treated are the optical and visual tracking of a satellite, satellite instrumentation, meteorological measurements from the vehicle, and the possibilities of other observations from the satellite.

Water Hammer: Its Cause, Magnitude, and Prevention. *By Oscar G. Goldman;* 116 *pages,* 6 *by* 9 *in., clothbound; published by and available from Columbia Graphs, Columbia, Conn.,* $5.00 *per copy.*

The engineer is assisted by this book in analyzing and calculating the intensity of water-hammer surge which might be developed within a system. Requirements of system design to eliminate it are given. The solutions presented in the book cover water-hammer problems of all types. The book provides a practical reference source directly useful to designers in this field.

Association Publications

Proceedings of the Symposium on High Temperature: A Tool for the Future. 218 *pages,* 8½ *by* 11 *in., clothbound; published by and available from Public Relations Dept., Stanford Research Institute, Menlo Park, Calif.,* $5.00 *per copy.*

The High Temperature Symposium was a jointly sponsored conference held at Berkeley in June 1956. The conference was distinguished by the fact that it dealt more broadly with the different phases of high-temperature

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research than any previous conference. The proceedings contain papers by 36 internationally recognized authorities. Three major areas covered are methods for reaching high temperatures, materials for containing high temperatures, and processes occurring at high temperatures.

Manufacturers' Publications

Comparative Heat Resistance of Fibers and Comparative Chemical Resistance of Fibers. *12 pages and 34 pages, both are 8½ by 11 in., paperbound; published by and available on letter-head request from E. I. DuPont de Nemours & Co. Inc., Technical Service Section, Textile Fibers Dept., Wilmington, Del.*

These two booklets describe chemical and heat resistance properties of various synthetic textile fibers. Comparative data is presented on the breaking tenacity, breaking strength, elongation and toughness of fibers after exposure to various chemicals. The booklet on heat resistance describes types of heat effects and the effect of heat upon the properties of various fibers.

Casting Kaiser Aluminum. *376 pages, 5½ by 8 in., clothbound; published by and available on letterhead request from Kaiser Aluminum and Chemical Sales, Inc., 919 N. Michigan Blvd., Chicago 11, Ill.*

This book discusses the more advanced methods used in designing and producing aluminum castings. Detailed data about aluminum and its alloys are provided for comparative purposes. Principle casting methods are discussed at length with material co-ordinated for practical interpretation and use. Aluminum has its own individual characteristics which influence melting, molding, and pouring practices. These features must be fully considered to obtain optimum production and satisfactory performance from castings.

RCA Receiving Tube Manual. *353 pages, 5½ by 8½ in., paperbound; published by and available from Radio*

Design Guide to

"Adjustable-Speed Drives"

- ELECTRICAL
- MECHANICAL
- HYDRAULIC

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Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

MACHINE DESIGN READER SERVICE

Penton Building
Cleveland 13, Ohio

Corporation of America, Tube Div., Commercial Engineering, Harrison, N. J., 75c per copy.

Manual RC-18 contains technical data on more than 575 receiving tubes, including types for black-and-white and color television and series-string applications. In addition, more than 75 picture tubes, including color types, are included. The manual covers basic tube theory and application information. The section on electron tube applications has been expanded over earlier issues to include a description of television application such as tuner circuits, video amplifiers, sync circuits, agc circuits, and deflection systems. Other sections include information on generic tube types, interpretation of tube data, and electron-tube installation.

Government Publications

Surface Treatments of Low Alloy Steels, PB 121507. *By Sam Tour; 203 pages, 8½ by 11 in., paperbound; published by Wright Air Development Center; available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.; $5.00 per copy.*

This report is a guide to the selection of surface treatments of low-alloy steels for corrosion and oxidation resistance at a minimum expense in critical materials. Forty metallic and nineteen paint types of heat resistant coatings applicable to plain carbon and low-alloy steels are described and evaluated. Relative temperature, corrosion and abrasion resistance are given. Formability, weldability, joining characteristics and costs are also discussed.

Index of NACA Technical Publications. *222 pages, 8½ by 10 in., paperbound; published by and available from National Advisory Committee for Aeronautics, 1924 F St., N. W., Washington 25, D.C.*

This index covers those NACA research reports issued in the period of June 1955 through June 1956. It is the fifth supplement to the basic 1919-1949 index. The research reports issued prior to June 1955 which have been declassified since that date have also been included.

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Circle 585 on page 19

"SHEAR-SEAL" 4-WAY VALVES, 0 TO 250 P.S.I. AIR

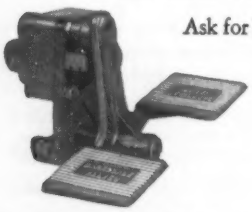
$18.50 List Price*

*$18.50 is the list price for the ¼" port size and $19.50 for the ⅜" less usual quantity discounts.

NO MORE AIR VALVE TROUBLES FROM DIRT OR CORROSION

(AND WITHOUT COSTLY FILTERS AND OILERS)

Important Savings	Low initial cost. Need no oilers and filters (time and materials savings).	All components are corrosion resistant.
Low Maintenance	Sealing qualities do not diminish with long, continued use.	Wear compensating "Shear-Seal" design.
Long Service Life	No production delays. Maintenance (rarely needed), without disturbing plumbing.	Lapped metal to metal sealing members.
Not Critical to Dirt	No scoring or binding. (As with spool or poppet designs.)	Flow is through "Shear-Seals." Sealing surfaces remain in constant intimate contact.
No Creeping Cylinders	Leakproof closure. (No internal port to port leakage.)	Maintained through lapping action of each operation.



Ask for bulletin A-5.

Foot operated models with or without spring return to reverse or to center are $24.50 list for the ¼" and $25.50 for the ⅜" valve less quantity discounts.

BARKSDALE VALVES

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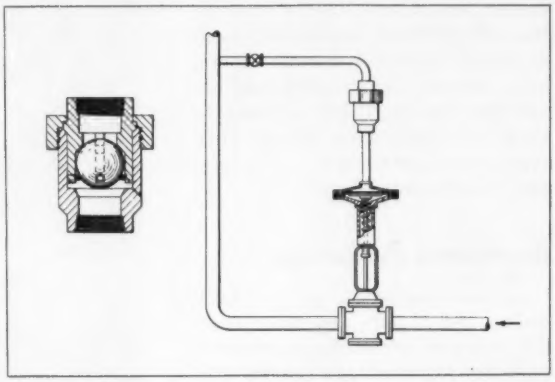
NOTEWORTHY Patents

Temperature-Responsive Check Valve

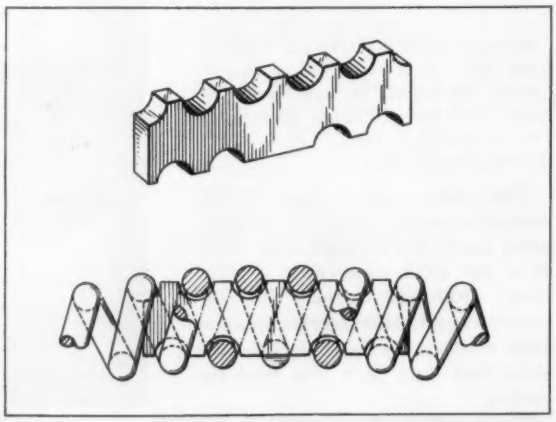
Fusible pins of low melting point alloy block operation of a temperature-responsive check valve under normal temperatures of the fluid being controlled.

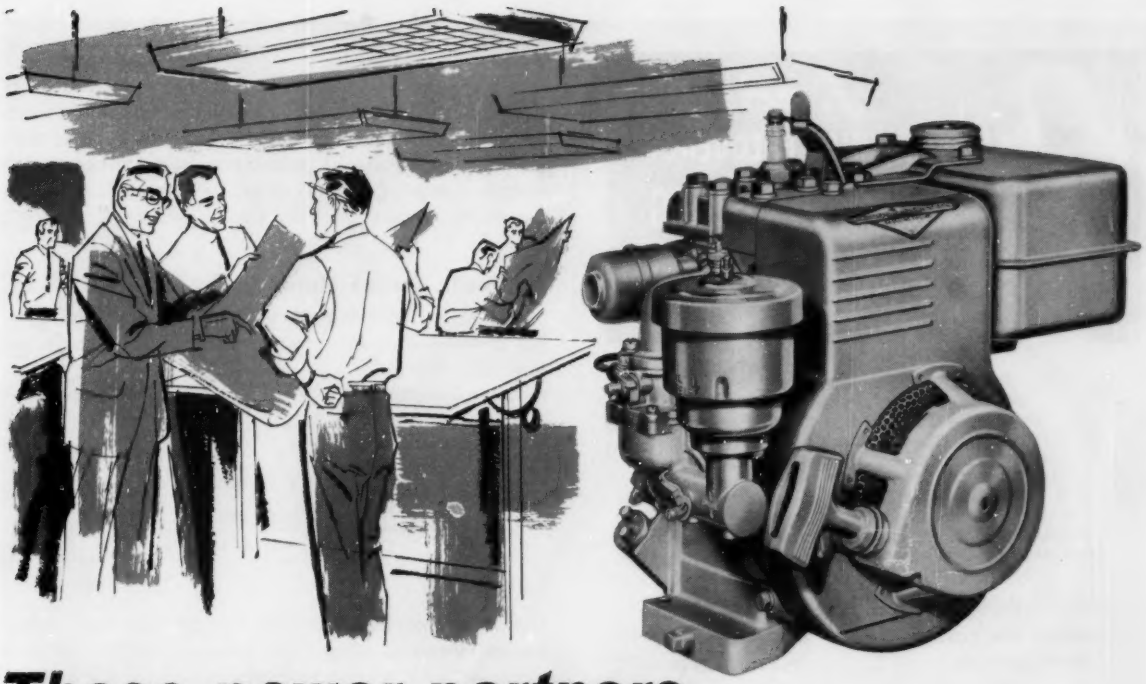


Exposure of the valve to excessively hot fluids, such as would occur with rupture of the diagram in a hot-oil control system (shown), melts the fusible pins, permitting actuation of the ball-check and preventing back-flow through the control-valve balance line. Alternate versions include a flapper-type check valve. *Patent* 2,774,366 *assigned to Standard Oil Co. by John R. Dado.*

Coil-Spring Connector

Free ends of an open-wound coil spring can be brought together to form a continuous spring loop by use of a flat connector. Designed for threading into the spring ends, the connector has evenly spaced notches on one edge, an interrupted series on the other. Central flat formed between the interrupted





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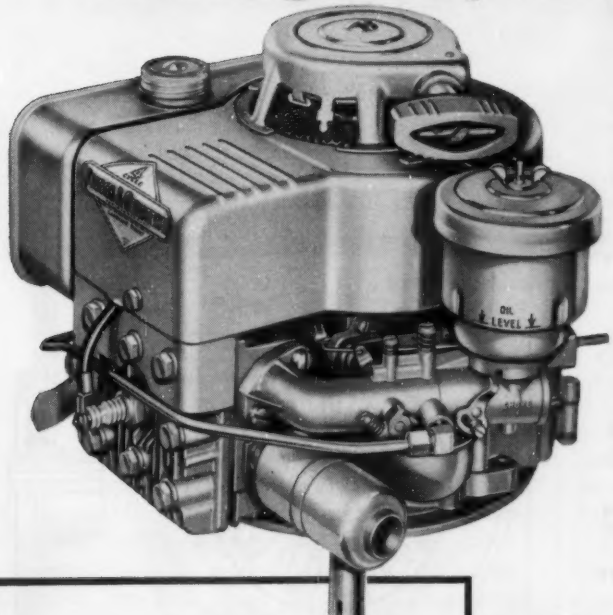

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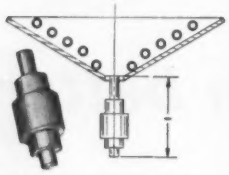
If you are interested in induction heating you are invited to send samples of the work with specifications. Our engineers will process and return the completed job with full data and recommendations without any cost or obligations.

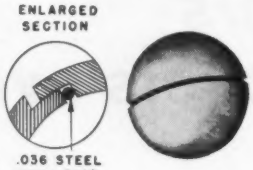
TYPICAL INDUCTION HEATING APPLICATIONS

TEMPERING FOR CUSTOM HEAT TREATING



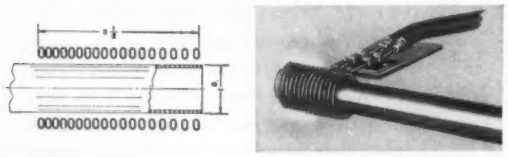
Selected areas of hardened steel parts may be tempered for fabrication or service requirements. Concentrator type coil permits high power density in restricted area thus minimizing heating time and permitting marked variation in properties in adjacent sections.

WIRE RING JOINS PLASTIC PARTS



High frequency induction heats wire ring which in turn heats plastic wall, providing sufficient plasticity to cause flow and bonding upon application of pressure. Metal to plastic seals are similarly performed.

ANNEALING ALUMINUM FURNITURE TUBING



Selective annealing of aluminum furniture tubing permits bending where required without loss of strength in adjacent portions of tube. Brass or steel tubing is also being selectively annealed.

Electronic Tube Generators from 1 kw to 100 kw.
Spark Gap Converters from 2 kw to 30 kw.

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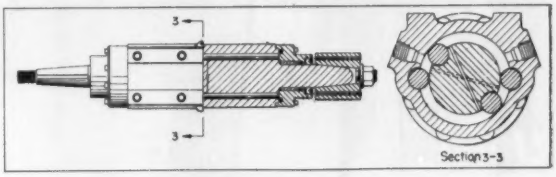
Noteworthy Patents

series of notches provides a common abutment surface for the spring ends, precluding angular movement of the connector about its axis. Typical uses include fabrication of annular spring expanders for certain types of piston rings. *Patent* 2,778,697 *assigned to France Packing Co. by Elmer R. Nuttall.*

Hydraulic Torque Motor

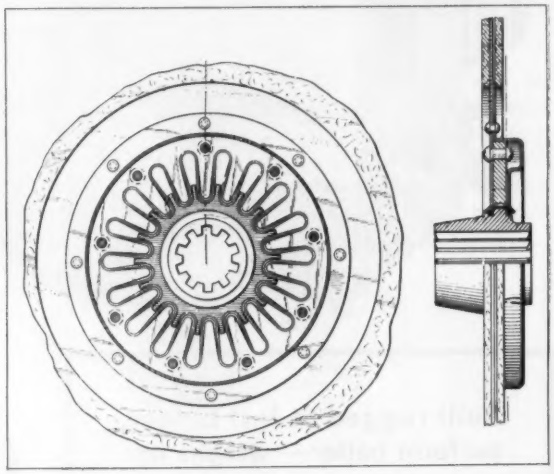
Cylindrical plastic rods, seated in mating semicircular grooves in both rotor and stator, serve as pressure-chamber dividing vanes in a hydraulic torque motor. Designed to give reciprocating rotational mo-



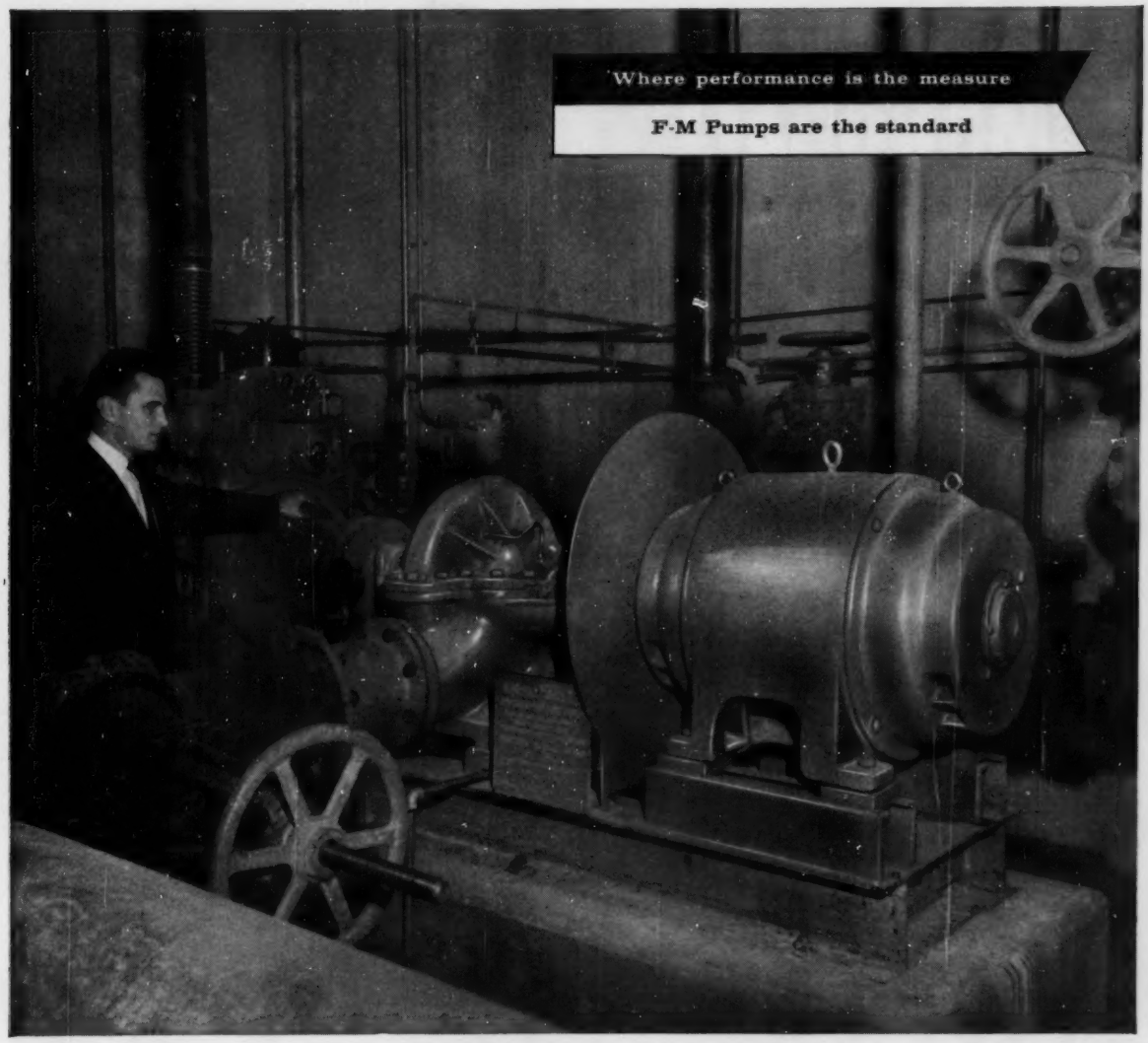
tion in an approximate 180-deg arc, the unit stator moves clockwise when fluid enters the left-hand port (Section 3-3), counterclockwise when pressure is applied to the right-hand port. Deformation of the plastic vanes under hydraulic pressure provides an effective seal between pressure-chamber sections. Typical use is for actuating scraper blades in road-building equipment. *Patent* 2,778,340 *assigned to F. J. McCarthy Inc. by Leo O. Greely.*

Torsional Vibration Absorber

Designed to absorb torque pulsations in rotating components such as clutches, brakes or intermittent-motion devices, a torsional vibration absorber comprises driving and driven members with loosely inter-



meshing teeth. Members are resiliently connected by a spring-steel strip. Distortion of the spring between meshing teeth permits limited relative angular movement between driving and driven members, and fluid entrapped in the tooth spaces provides vibration damping for the device. *Patent* 2,755,105 *assigned to New Products Corp. by Oscar H. Banker.*



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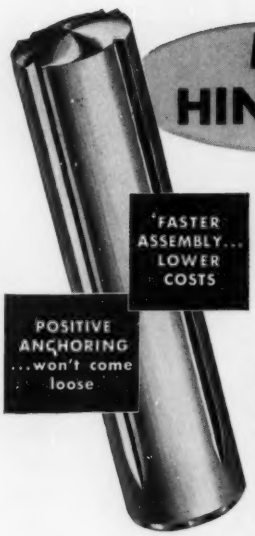
Circle 590 on page 19



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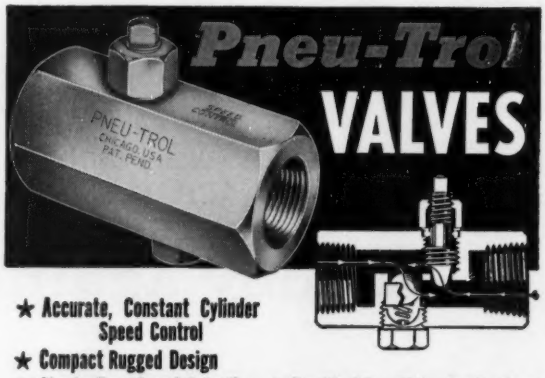
Circle 591 on page 19



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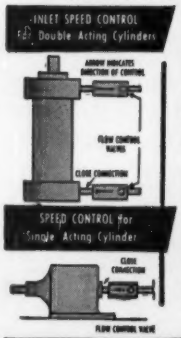
★ Compact Rugged Design
★ Simple, Easy Speed Selection ★ For Air, Oil or Water Applications



Pneu-Trol Speed Control Valves, are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

Needle design permits maximum flow capacity in the controlled direction. Metal to metal needle and ball seats insure long trouble-free service. Simple, practical "O" gland structure eliminates troublesome leaking. Valve bodies machined from hex brass or aluminum for 2000 psi working pressures; steel and stainless steel for 5000 psi. Made in 5 female pipe sizes—⅛" to ¾". ATTRACTIVE PRICES . . . IMMEDIATE DELIVERY.

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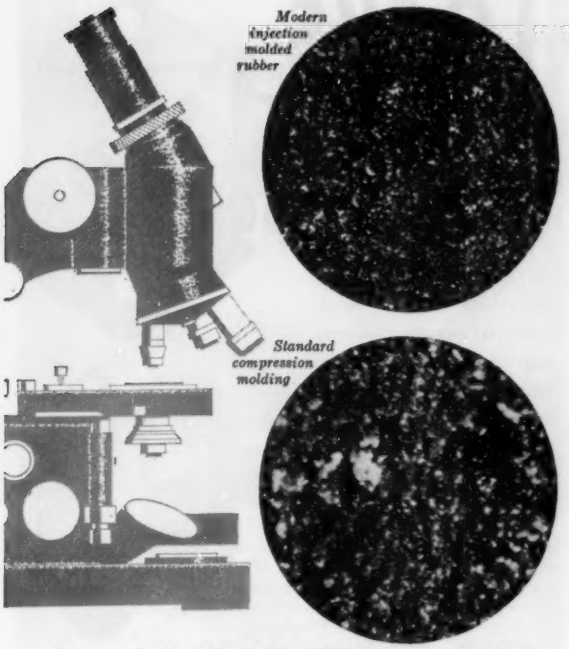

How injection molding can help you solve design problems, improve products with rubber parts . . .

Greater density produced by injection molding is shown in comparison to ordinary compression molding. Injection molded rubber (top) displays homogeneous characteristics unequalled for consistency or toughness by any other process. In application this will mean tremendous resistance to abrasion and chemical action—much longer rubber part life. Both microphotographs are standard Buna N compound, approx. .269″ x .019″, magnified 240 diameters by the University of Minnesota.

Injection molding of organic, synthetic and silicone rubber compounds offers you the key to optimum performance from rubber parts. Minnesota Rubber uses an exclusive injection molding process that provides matchless product consistency and tolerances as close as .002 inch. Complete facilities and mass production techniques assure lower production costs. Statistical sampling and laboratory analysis at every production stage keep tolerances and quality consistent.

Economy in product development and production can be yours because: *injection molding* eliminates "flash" and similar finish imperfections—no trimming required; *injection molding* permits fast fabrication and delivery—no expediting costs; *injection molding* assures consistent quality to meet your requirements—saves replacement costs. In addition, custom compounding and laboratory facilities for research, problem analysis and product development are offered to you by Minnesota Rubber.

Types of parts available at Minnesota Rubber in a full range of compounds are:

1. Custom Molded—a limitless variety of shapes, sizes and types.
2. Metal Bonded—injection molding assures tight bonds, closer tolerances.
3. Sub-miniature—*example*: part with round cross section of .020″.
4. Seals—full range of O-rings and QUAD® RING standard sizes stocked.

Samples and detailed data will be forwarded to you on request. Please specify product interest. Write . . .

QUAD RING is a Trade Mark of

MINNESOTA RUBBER & GASKET CO.

Originators of modern rubber injection molding

Dept. 807, 3630 Wooddale Ave., Minneapolis 16, Minn., WEst 9-6781

Circle 593 on page 19

If you'll show us the small machined parts you use . . .

we'll show you how you can save up to 70%

on parts that do a better job

Cold-formed parts by Progressive's modern methods are saving users of small parts thousands of dollars yearly. For each machining or other production operation that you can eliminate (without the loss of mechanical values), means savings to you in time, money and metal. *Savings that run as high as 70%.*

QUOTATIONS - How to get a good one . . . *FAST*

Send us samples, dimensions, material specifications, and drawing. This can be a rough sketch if dimensions are clearly and accurately indicated. Knowing quantities and what the part does will help to give you the best cost we know how. We'll go to work at once, and you'll have a firm Progressive figure to help you cut your costs. Check your machined parts today. We'll start to work opening a Progressive "savings-account" as soon as we hear from you.

Machine screws and special fasteners are our business . . .
including square and hexagon machine screw nuts, Sems fasteners, slotted tapping screws and Phillips Head Screws

STANDARDS AND SPECIALS CUSTOMIZED FOR YOUR NEEDS

THE PROGRESSIVE MFG. CO.

Division of The Torrington Company

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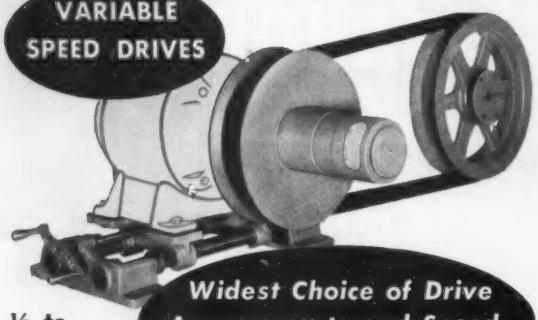
Circle 594 on page 19

ROTO-CONE

VARIABLE SPEED DRIVES



1/8 to 20 H.P.

Widest Choice of Drive Arrangements and Speed Ratios — All V to V.

When your plans call for variable speed it isn't necessary to use a cumbersome, expensive motor drive. Simple to install, Roto-Cone drives operate on the V to V principle providing up to 40% more pulling power and greater belt life.

Belt travels on a fixed center line as exclusive operating principle provides equal and opposite lateral movement of *both* discs of Roto-Cone variable speed pulley. Up to 8 to 1 speed change ratio. Sizes from 1/8 to 20 H.P. The Roto-Cone line is complete . . . variable speed pulleys, standard and countershaft adjustable motor bases, V-Belts, and V-driven sheaves. *Write for 30-page catalog.*

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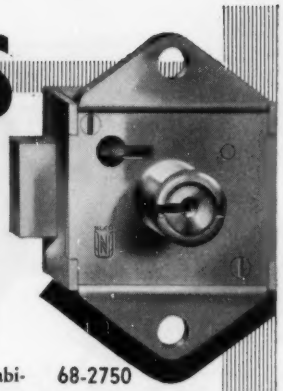
Circle 595 on page 19

LOCKS by National Lock



68-2750

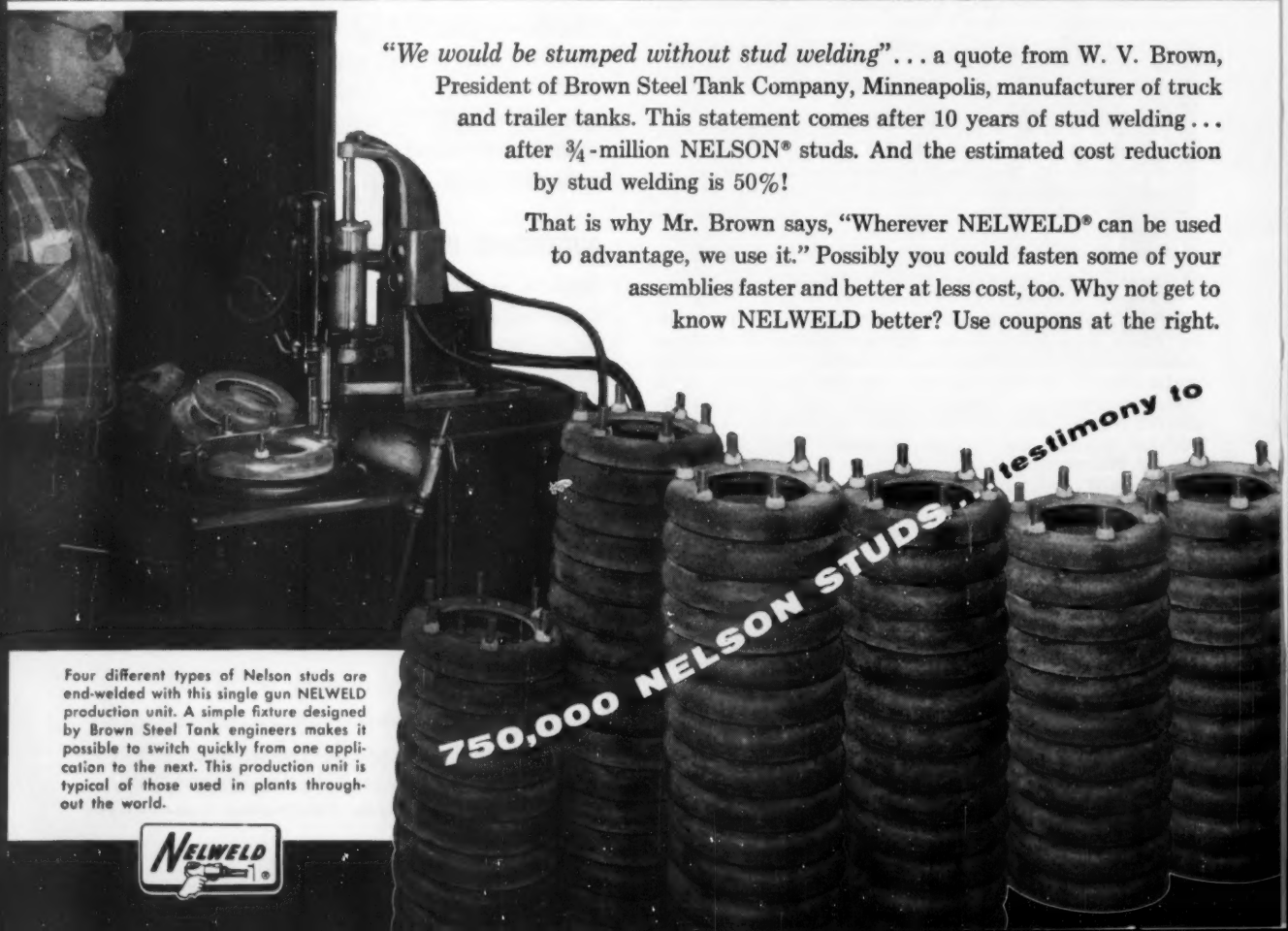
For a wide variety of metal products, including lockers, cabinets, control boxes, office equipment, etc. Selection of lock types (plate, lever and pin tumbler), sizes and finishes. Let our sales engineers work with you in recommending the lock (standard or special) to best meet your requirements.

68-157

Write for Lock Catalog 156

NATIONAL LOCK COMPANY
Rockford, Illinois

Circle 596 on page 19



"*We would be stumped without stud welding*"... a quote from W. V. Brown, President of Brown Steel Tank Company, Minneapolis, manufacturer of truck and trailer tanks. This statement comes after 10 years of stud welding... after ¾-million NELSON® studs. And the estimated cost reduction by stud welding is 50%!

That is why Mr. Brown says, "Wherever NELWELD® can be used to advantage, we use it." Possibly you could fasten some of your assemblies faster and better at less cost, too. Why not get to know NELWELD better? Use coupons at the right.

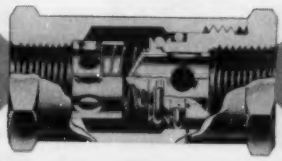
750,000 NELSON STUDS... testimony to

Four different types of Nelson studs are end-welded with this single gun NELWELD production unit. A simple fixture designed by Brown Steel Tank engineers makes it possible to switch quickly from one application to the next. This production unit is typical of those used in plants throughout the world.

NELWELD®

the only truly

LEAKPROOF CHECK VALVE



Circle Seal valves are truly—the only 100% **reliable** leak-proof check valves. The Circle Seal "O" Ring sealing principle guarantees it! Years of use in many industrial applications proves it!

Zero leakage, 0-3000 psi
Unrestricted Flow
Low Cracking Pressure

Get complete engineering data now.

Circle Seal Representatives throughout the United States

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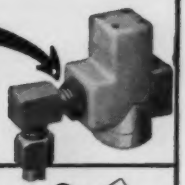
Circle 597 on page 19

STOPS PIPE THREAD LEAKS

PAT. PENDING



Satisfaction Guaranteed Or Money Back TRIAL OFFER

TRU-O-SEAL Fittings are guaranteed to seal pipe thread connections permanently against all oils, practically all known chemicals and gases; to seal under high pressures or vacuum; to withstand —280° to plus 500° F.; to eliminate "overtightening" damage and pipe dope. Available in ⅛" to 2½" pipe thread sizes.

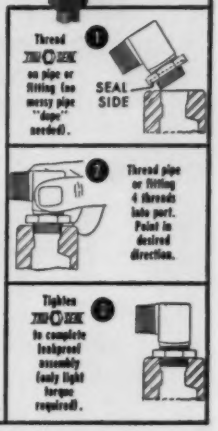
$10.00 Trial Offer No. 1: eight ⅛", ten ¼", eight ⅜", ten ½" pipe thread TRU-O-SEAL Fittings.

$10.00 Trial Offer No. 2: eight ½", ten ¾", four 1" pipe thread TRU-O-SEAL Fittings.

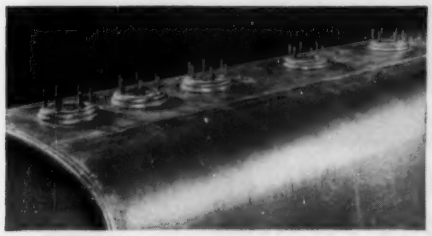
Send order to

TRU-O-SEAL DIVISION
Flick-Reedy Corporation
2006 N. Hawthorne Melrose Park, Ill.

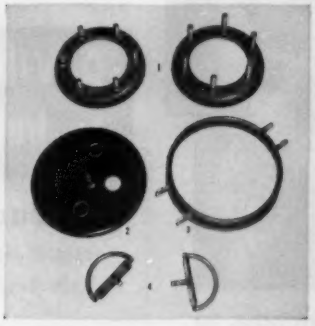
"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.


1
Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).
SEAL SIDE
2
Thread pipe or fitting 4 threads into port. Point in desired direction.
3
Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).

Circle 598 on page 19



Tank drain sumps with NELSON threaded studs are hand-welded to truck tank.



NELSON granular flux filled studs of various types are used in the fabrication of Brown truck tanks: (1) Six threaded studs end-welded to drain sumps, (2) threaded stud centered in fill cap, (3) fill cap neck with four hinge studs, (4) square studs on door lock handles.

50% cost reduction, leak-proof tanks

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Check here ○ if you would like us to send you a folder of cost-saving NELWELD applications.

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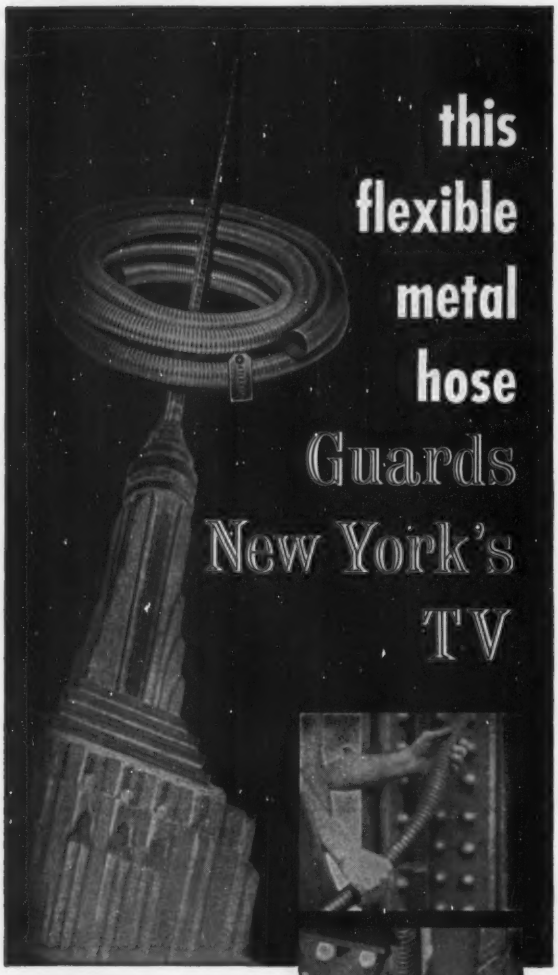
Check here ○ if you would like a free subscription to the NELWELDER, industry's magazine of cost-saving ideas based on stud welding.

Circle 599 on page 19

NELSON STUD WELDING . . . *Division of Gregory Industries, Inc., Lorain, Ohio*



—another example of how Atlantic's engineers and ingenuity devise new solutions to new problems.

The $1,000,000 tower atop the Empire State building was designed to usher in a new era in TV transmission and reception. Its construction required an unprecedented number of circuits to travel up a tower often of less than two feet square. The conduit, enclosing the cables, had to be extremely *flexible* to avoid splice plates, rivet heads and diagonal braces in the steel work. It had to be permanently weather tight.

Ordinary rigid and flexible metal conduit failed! Atlantic's engineers in cooperation with the RCA Service Co. designed a heavy duty, high pressure bronze hose that did the job and also saved many costly and hazardous man hours of work. This hose was JOB TESTED and CERTIFIED.

Our engineers will help solve *your* problems in weather protection . . . flexibility . . . conveying . . . controlling pressure, movement and vibration . . . correcting misalignments. Seamless and Interlocking Hose. Bronze, Steel, Stainless Steel, Monel. ⅛"-36" I.D. with proper fittings. Write for Bulletin #500A See our Catalog in Sweet's Product Design File.

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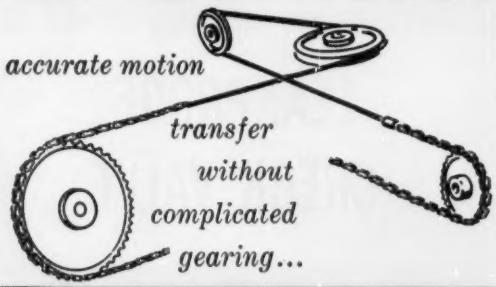

SIERRA MINIATURE MECHANICAL CHAIN AND SPROCKETS...

Provide precise, positive motion transfer through several planes simultaneously with no cable slippage...no complicated gearing. Unlimited center-to-center selection for miniature and sub-miniature assemblies in servo systems, gyro systems, special cameras, electronic equipment, and small precision instruments. Less weight, cost, maintenance —wider tolerances. Designed to operate around minimum 7-tooth sprocket with root diameter of .250 inches. Chain pitch .1475 inches; Weight .45 oz. per lineal ft. Material: stainless steel, or other materials, including non-magnetic beryllium copper.

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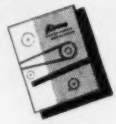


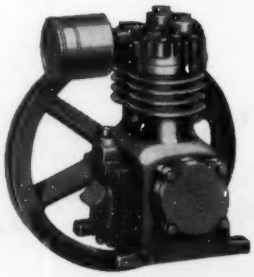
Contains useful application data, specifications, tables on chain pitch and sprocket sizes, suggestions for calculating center-to-center distance. *Write for yours today.*

T. M. REG.

Circle 601 on page 19

DeVilbiss Air Compressors to build into your product

Quality-built, efficient, long service life



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Gain the benefits of all the research, development, and experience DeVilbiss has put into air compressors for quiet, smooth operation, and easy maintenance. Choose from V-type or upright-type, single- or two-stage, ½ through 15 hp, and pressures up to 200 psi. Displacement ranges from .82 cfm to 66.3 cfm.

DeVilbiss compressors are cool-running; pay for themselves, because they deliver as much as 22.6% *more* air per power dollar than most others! Write for Bulletins CL-b, and F-272-A, now!

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DEVILBISS

Circle 600 on page 19

Circle 602 on page 19

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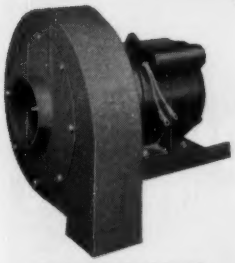
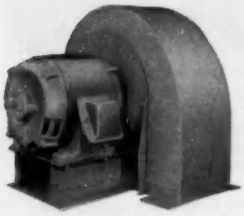


ELECTRONIC COOLING



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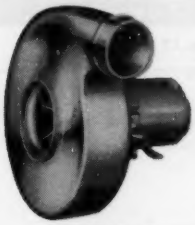
INSULATED FOR TEMPERATURES



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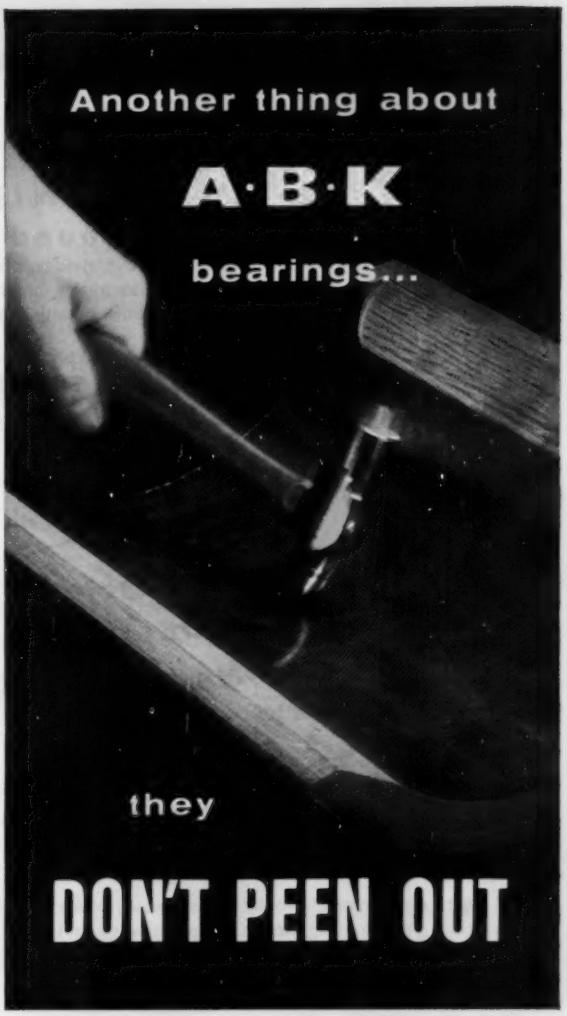

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It can be formed, machined to intricate shapes. It can be bonded to metal. It can be lubricated with water or oil. It often performs better, lasts longer than metal.

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AMERICAN Brake Shoe COMPANY

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Circle 603 on page 19

Circle 604 on page 19

COES KNIFE COMPANY

Precision Ground Machine Ways

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MACHINE KNIVES

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COES MICRO GROUND

Circle 605 on page 19

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time switches—
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lighting—equipment control—all applications requiring complete reliability and long service life.

All parts are accessible—readily inspected, easily replaced. Full floating armature permits perfect magnetic seating, silences AC hum.

Contacts are copper to copper. Heavy compression springs assure contact pressure, quick opening. Coil will not overheat in 24-hr. continuous service.

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Circle 606 on page 19

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Gears made only to your specifications. None carried in stock.

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PG PROCESS GEAR CO., INC.

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Circle 607 on page 19

Design Manual

"MECHANICAL ADJUSTABLE-SPEED DRIVES"

Parts I & II
by Leo F. Spector

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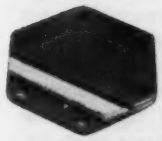
Circle 608 on page 19

Stalwart silicone parts are solving more and more engineering problems for more and more products

7338-SR

Specially recommended for high and low temperature applications



Silicone rubber parts by Stalwart are solving problems every day . . . and costs are being cut too!

Time and again, Stalwart Engineers have and will replace costly metal constructions forced on design engineers because of the limited thermal stability of organic rubbers.

Stalwart is prepared to produce precision parts from a variety of Silicone rubber stocks to meet your individual specifications. These parts will retain rubber-like properties at temperatures from −130° to +600° F. They will have excellent dielectric properties and resist compression set.

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180 Northfield Road • Bedford, Ohio

Manufacturing Plants in Bedford, Ohio and Jasper, Georgia
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Circle 609 on page 19

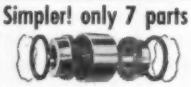
with *Sier-Bath* Flexible Gear Couplings

Costs Go DOWN as Horsepower Ratings Go UP

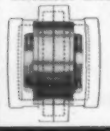
Where horsepower loads are heaviest . . . that's where Sier-Bath Flexible Couplings are stand-outs in performance and economy! Not only are Sier-Bath Coupling capacities higher for any given shaft size from 3" to 12", but also their *initial cost to you averages 21-percent lower* (compared to four other leading brands).

You save many ways with Sier-Bath Couplings, because simplicity of design makes possible great savings in space and weight, requiring *less* shaft space for assembly . . . and use of snap-rings instead of flanges and bolts cuts assembling and uncoupling time to seconds, eliminating special tools. Lower moment of inertia reduces bending stresses on shafts, saves bearing wear.

Simpler! only 7 parts



Smaller and Lighter!



3/5 Usual Size

1/2 Usual Weight

Sier-Bath Flexible Gear Couplings are available in many standard and special types in sizes from 7/8 to 12. Horsepower ratings range from 4 to 4500 HP/100 rpm.

Complete catalog information will be sent on request

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Light Military Electronic Equipment Dept.

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Circle 611 on page 19

Design Guide to

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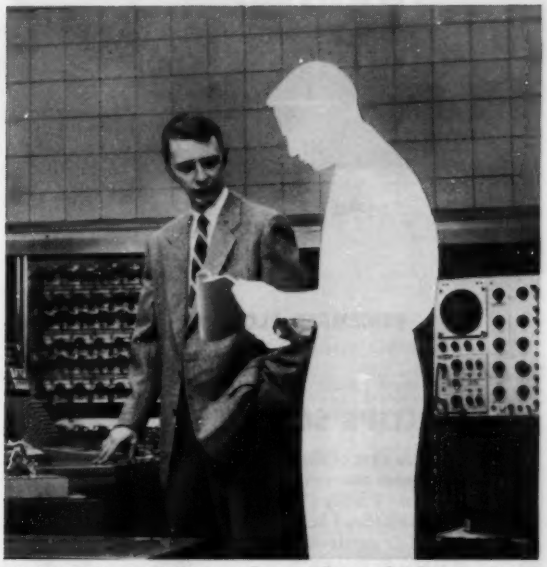

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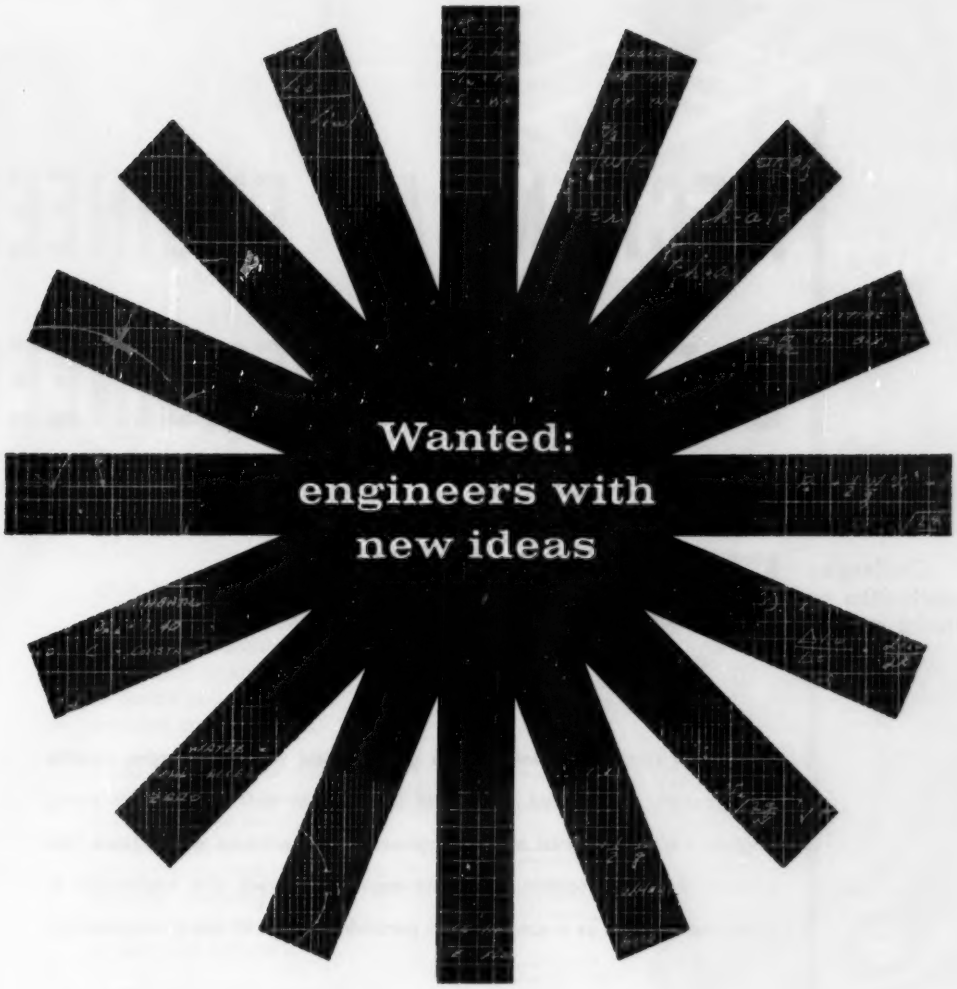

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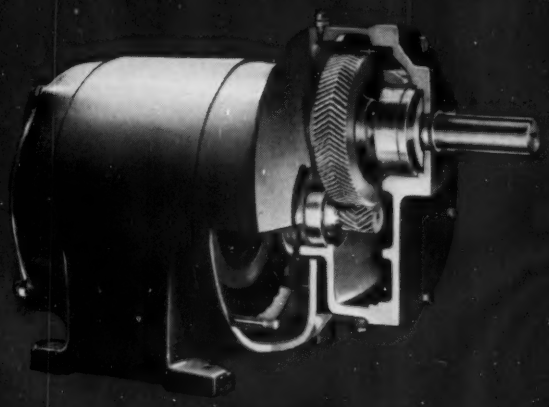

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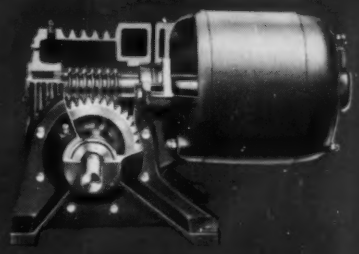

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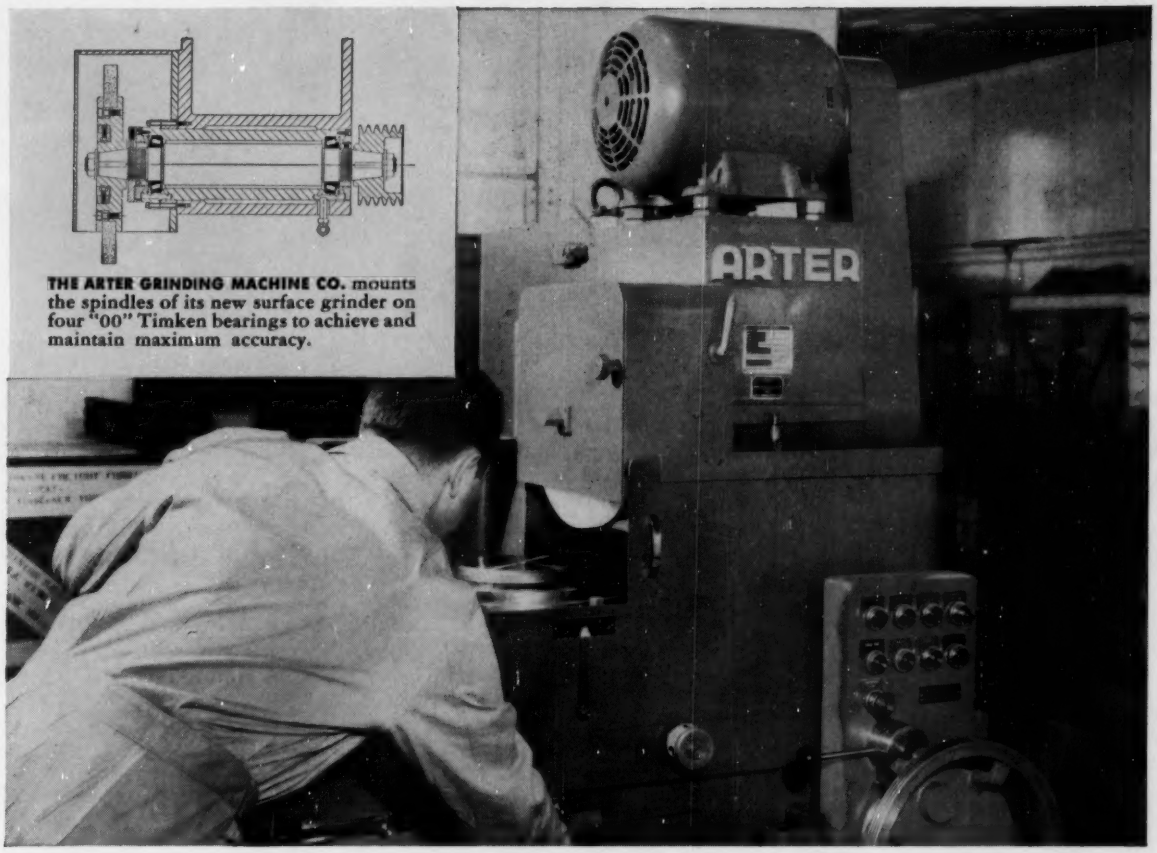

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